
CONCRETE
MASONRY
MANUAL

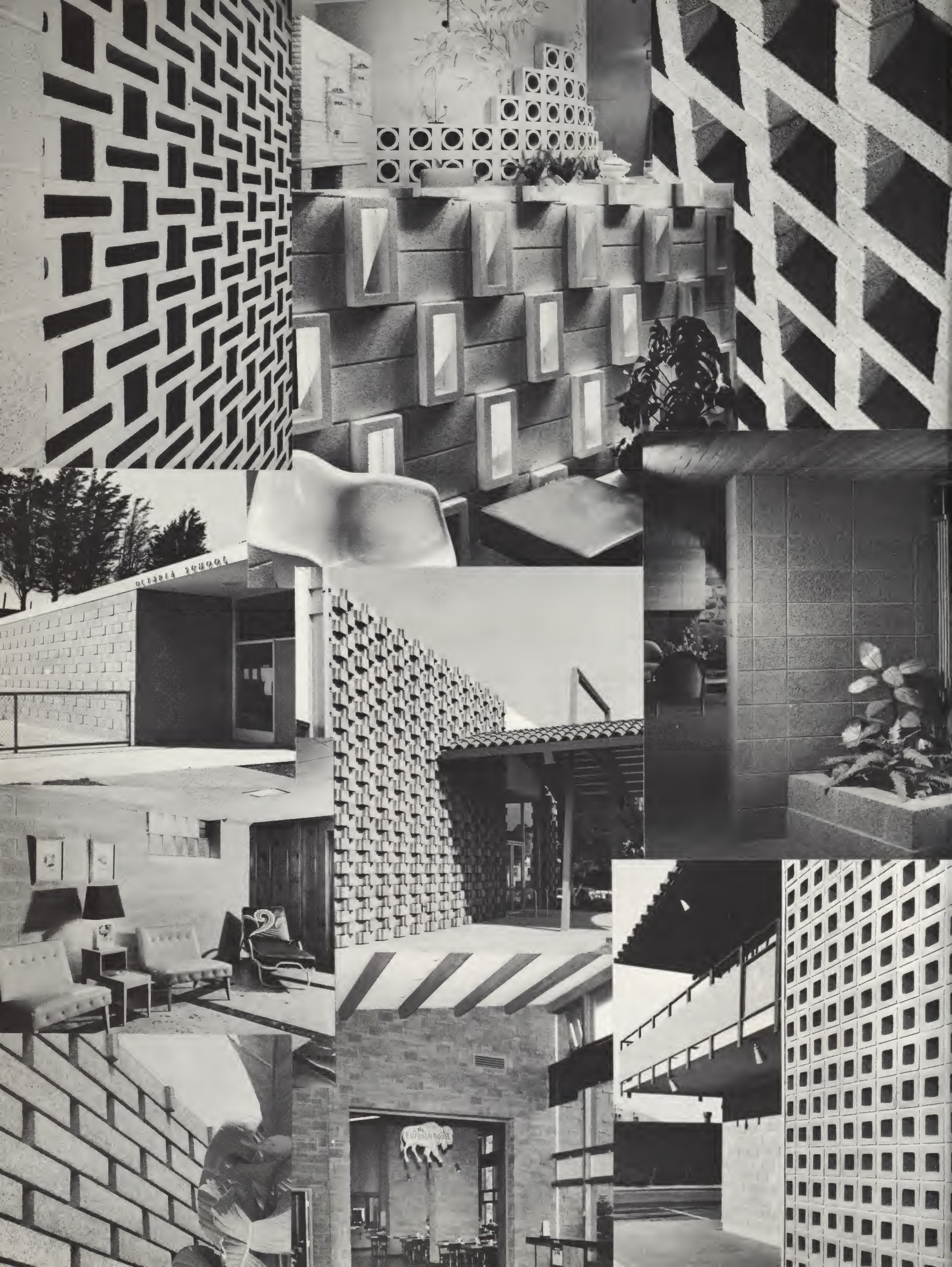
Foreword

Statistics vouch for the increasing awareness of Architects, Engineers, Contractors and Owners to the value and economy of expanded shale concrete masonry walls. From the lowly, stone-imitating concrete blocks of a few decades ago, has evolved lightweight concrete masonry vastly improved in utilitarian function, making possible the construction of walls combining the utmost in safety with natural inherent beauty.

This manual has been prepared to present in concise form the basic facts about expanded shale masonry. It brings between one set of covers the results of studies, research and experience from many sources, and references to other valuable literature on the subject. This compilation is designed to acquaint the building industry with the advantages and economies of expanded shale masonry construction.

Consult with Institute members for assistance relating to specifications, details and sources of expanded shale masonry for your building construction.

EXPANDED SHALE CLAY & SLATE INSTITUTE


the
BUFFALO ROOM

CONCRETE MASONRY MANUAL

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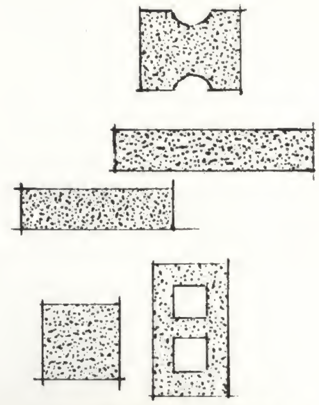
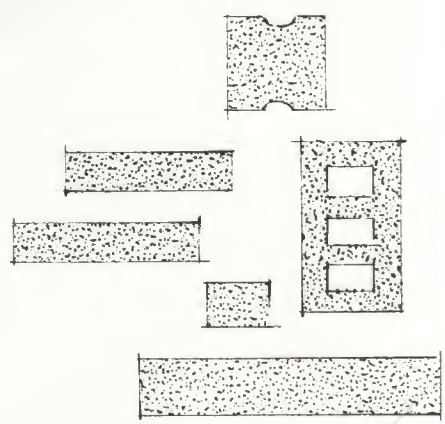
section

Definition

of Expanded Shale





Expanded shale is a processed lightweight aggregate produced by expansion and vesiculation under scientific control of raw shale, slates or clays having suitable characteristics and at kiln temperatures of from 1900 to 2200° F. Gases formed within the shale thus expand, forming myriads of tiny air cells within the mass, which are retained upon cooling and solidification. The resultant product is therefore made up of a cellular aggregate of great structural strength, each cell being surrounded by a hard vitreous membrane.

Expanded shale has been recognized by the building industry as a high grade building material for more than a third of a century. The process was first perfected at Kansas City in 1917 by Stephen J. Hayde, a chemist, who found that by heating certain shales, clays and slates to incipient fusion he was able to develop a lightweight aggregate of high structural strength.

Section **1.**

CONCRETE MASONRY CONSTRUCTION

GENERAL

The increasing use of expanded shale concrete masonry for exposed walls, particularly in the finer types of construction — churches, schools, residences, offices, and others — is the result of its performance record. This has been achieved through the imaginative designs of the Architect, the skilled workmanship of the Mason, as well as the splendid quality of the masonry unit. The following points are conducive to good lightweight concrete masonry construction:

(1) DESIGN

(2) QUALITY MATERIALS

(3) CARE IN HANDLING AND STORAGE OF MATERIALS

(4) SUITABLE MORTARS

(5) SKILLED AND CAREFUL WORKMANSHIP

(6) DETAILS OF CONSTRUCTION

(7) NECESSARY CLEANING-UP

DESIGN

Without the technical knowledge, experience, imagination, and the interest of the Architect in his designs, it is doubtful if lightweight concrete masonry would be enjoying its prominence in the construction field today. His creative touch in transforming an otherwise utilitarian building into a glamorous, functional structure must also include efficient construction and structural concepts.

For example, in the control of possible cracking of masonry walls he may incorporate bond beams and/or control joints into the architectural treatment. In another case he will fit into his architectural design the structural stability necessary to resist earthquake stresses.

This Manual has been prepared with sections discussing the properties of expanded shale concrete masonry and with recommendations to aid the Architect in his designs.

QUALITY OF MATERIALS

The designer should choose materials which not only provide the required strength with the necessary degree of fire resistance, acoustical value, thermal insulation, etc., but for the exposed walls he must also consider the finished appearance. Beauty of finished walls require a uniformity of texture, achieved by the use of units of uniform quality.

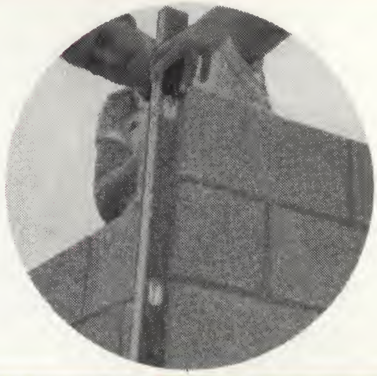
The extent to which these factors and others are obtained with expanded shale masonry is discussed under the appropriate headings of this manual.

NCMA Photo

BRIEFLY, SOME OF THE IMPORTANT POINTS TO BE FOLLOWED ARE:

1 The first course should be laid with care, making sure it is properly aligned, levelled and plumbed. If the first course is laid out properly it will be easier to maintain proper bond in later courses. The first course should be laid in a full bed of mortar.

2 Corners should be laid prior to the mid-portion of the wall, and care should again be taken to level, align, and plumb. This simplifies the laying of the mid portion of the wall.



3 Concrete masonry units should be laid with the thicker edge of the face shell up to provide a wider mortar bed. Both face shell and ends of all blocks should receive a full bed of mortar. Cross webs should be mortared if required by the specifications.

4 Mortar which is sufficiently workable should be used. (See Mortars). If it is necessary to adjust the blocks after the mortar has stiffened, all old mortar should be removed and fresh mortar applied.

HANDLING AND STORAGE

Masonry units should be handled with reasonable care at the plant, during shipment, and at the site. It should be realized that expanded shale masonry units are used as a finished wall and, as with other finish materials, should be treated with reasonable care to prevent undue damage.

Masonry units should be stored on planks, pallets or skips at the job and the storage piles should be covered with a tarpaulin or other protective covering to prevent excessive wetting. At no time, should wetting of the block prior to laying be permitted.

MORTARS

Good mortar is an essential ingredient to a finished wall. With properly designed mortars the mason is able to lay up a sound, good appearing wall which will perform as expected. The subject of mortars is discussed on page 36.

LAYING UP THE WALL

The role of the mason in laying up the wall and its effect on the final results, cannot be overemphasized. As with any other building material, expanded shale masonry walls depend on the workmanship of the craftsman to extract their full effectiveness. Skill in laying masonry is a result of training and experience, coupled with interest and pride of accomplishment. While it cannot be taught from books alone, there are publications which offer help to the mason in achieving the best results. "Recommended Practices for Laying Concrete Block" published by the Portland Cement Association is such a publication. It describes and illustrates step by step procedures in laying the concrete masonry wall for best results.

TOOLING

While any of the various types of joints may be used with concrete masonry, either concave or V-shaped joints are preferred for general use. They provide a tight joint with good appearance. Tooling should be done with a jointer at least 22 in. long, and up-turned on one end to prevent gouging of mortar. After the joints have been tooled, any mortar burrs should be trimmed off flush with the face of the wall with a trowel or removed by rubbing with a burlap bag.

PROTECTION

At the end of the day's work all masonry walls should be covered with building paper or tarpaulins to prevent the entrance of rain or snow into the cores and to keep the masonry as dry as possible.

CONSTRUCTION DETAILS

Plans should be studied in advance to ensure that all special details are taken care of as the construction proceeds. Special units, plain-end units, sash jamb units, lintel units, etc. should be used where required. Solid units, bond beam units or masonry units with cores filled should be used under joists or under concentrated loads or wherever else specified. Where the cores of block are to be filled, the joint below the units to be filled should be covered with metal lath or a similar product to act as a core stop so as to ensure complete filling of the cores with concrete. Note should be made of the location of anchor bolts, control joints, and abutting walls and provision should be made for these as construction proceeds.

INTERSECTING NONBEARING WALLS

For tying nonbearing block walls to other walls, strips of metal lath or ¼-in. mesh galvanized hardware cloth are placed across the joint between the two walls. The metal strips are placed in alternate courses in the wall. When one wall is constructed first, the metal strips are built into the wall and later tied into the mortar joint of the second wall. Where the two walls meet, the vertical mortar joint is raked out to a depth of ¾ in. if it is exposed to view in the finished building, and calking compound is packed into this recess.

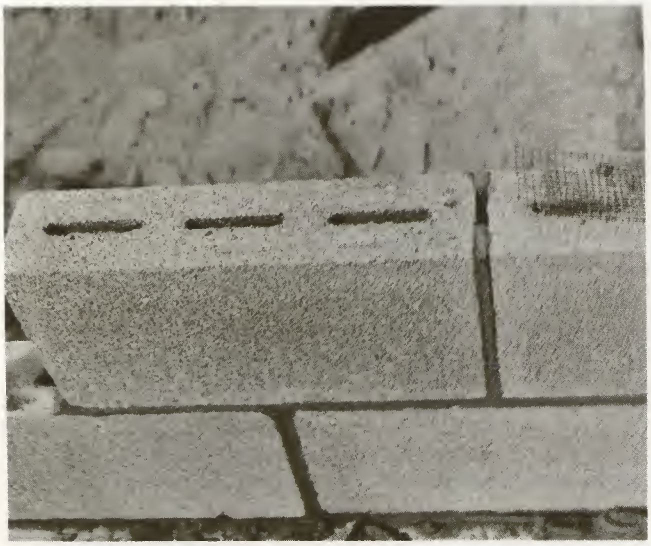
INTERSECTING BEARING WALLS

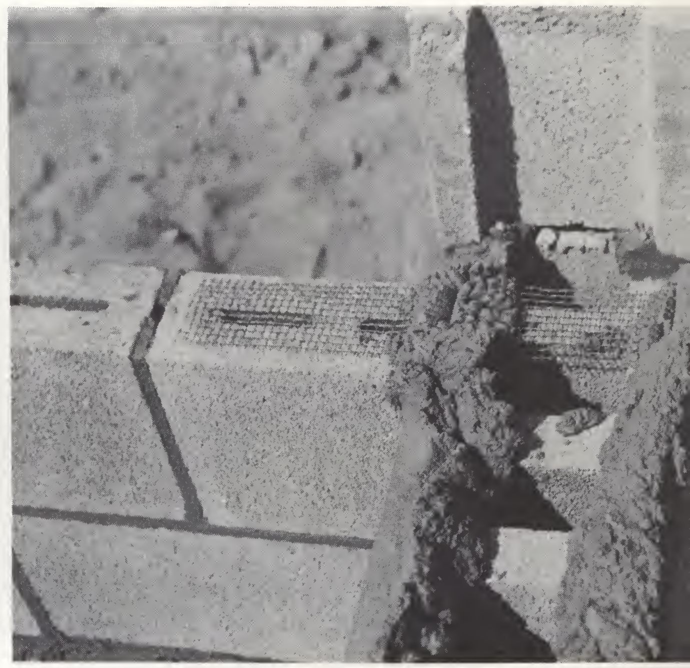
Intersecting concrete block bearing walls should not be tied together in a masonry bond, except at the corners. Instead, one wall should terminate at the face of the other wall with a control joint at that point. For lateral support, bearing walls are tied together with a metal tiebar ¼ in. thick, 1¼ in. wide and 28 in. long, with 2-in. right angle bends on each end. These tiebars are spaced not over 4 ft. apart vertically. The bends at the ends of the tiebars are embedded in cores filled with mortar or concrete. Pieces of metal lath placed under the cores support the concrete or mortar filling.

If the control joint at the intersection of the two bearing walls is to be exposed to view or the weather, it should be constructed and sealed with a calking compound.

CLEANING

Care should be taken in laying open textured expanded shale blocks to avoid excessive smearing of the mortar on the face of the units. Once hardened, embedded mortar smears or mortar droppings are difficult to remove, and therefore they should be removed immediately. It is preferable to allow them to dry for a brief period and then to remove with a trowel, followed by brushing with a wire brush. The wire brush should be used with care so as not to damage the mortar joint.





REFERENCES

1. Concrete Masonry Handbook
   Portland Cement Association

2. Recommended Practices for Laying Concrete Block
   Portland Cement Association

3. Concrete Masonry Foundation Walls
   National Concrete Masonry Association

4. Design and Construction of Lintels for Concrete Masonry Buildings
   National Concrete Masonry Association

Section 2.

SUGGESTED SPECIFICATIONS

Quality concrete masonry construction depends not only on the high quality masonry unit but also on good design, good mortar, and good workmanship.

Manufacturers of lightweight concrete masonry from expanded shale, clay and slate produced by members of the Institute, are furnishing the construction industry a product of highest quality. In an effort to aid the architect in making the utmost use of this product, these "Suggested Masonry Specifications" are offered as a guide. On some projects certain items will not be applicable to the masonry specifications. The specification writer should feel free to use those sections which pertain to the specific job and delete those sections which may not apply.

GENERAL

The masonry Contractor shall supply all labor, materials, and equipment necessary to complete the lightweight concrete masonry walls of this project in accordance with plans and specifications. This work shall be properly coordinated with that of other trades. All applicable local laws, ordinances and codes shall be fully complied with. All materials, workmanship and construction practices shall be of a standard not less than that shown on the plans or specified hereunder.

MASONRY UNITS

All concrete masonry units shall be manufactured from expanded shale, clay or slate aggregates, produced by the rotary kiln process, and conforming with A.S.T.M. Designation: C331 "Lightweight Aggregates for Concrete Masonry Units."

All concrete masonry units shall conform with A.S.T.M. Designation*:

- C 90 "Hollow Load-Bearing Concrete Masonry Units"
- C129 "Hollow Non-Load-Bearing Concrete Masonry Units"
- C145 "Solid Load-Bearing Concrete Masonry Units"

*Delete specifications not applicable.

CARE OF MASONRY UNITS

Masonry units shall be stacked on planks off the ground, and in wet weather shall be covered with tarpaulins or otherwise kept dry. At the end of each day's work the top of the wall shall be covered with tar paper, polyethelene sheets, or by other means protected from becoming excessively wet. The masonry units shall not be dampened prior to laying but shall be laid in the dry state. (Exception: See page 39.)

MORTAR

Mortar shall comply with A.S.T.M. Designation: C270 "Mortar for Unit Masonry" either Property Specifications or Proportion Specifications* except that type O and K mortars shall not be permitted.

PROPERTY SPECIFICATIONS

Mortar shall comply with A.S.T.M. C270 in all respects as it applies to property specifications. Local available plasticizers may be used when approved by the Architect and where tests show the mortar meets the requirements of these specifications. Mortar shall be type M, S, N (state which) and have minimum compressive strength and water retention shown in Table 1, when tested in accordance with A.S.T.M. C270.

PROPORTION SPECIFICATIONS

Mortar shall comply with A.S.T.M. C270 "Mortars for Unit Masonry", with proportions as shown in Table 2 (Note: Where local tests and usage have indicated other admixtures and plasticizers and larger quantities of sand, the proportions of these may be substituted by the Architect). Mortar shall be type M, S, N (state which).

RETEMPERING

Mortar that has stiffened on the mortar board, caused by evaporation, may be retempered to restore its workability by thorough re-mixing and by the addition of water as required. Mortar which has stiffened on the board by hydration (setting) shall not be re-used and shall be discarded.

*Specify either "Property" or "Proportion", not both.

TABLE 1

Minimum Strength and Water Retention of Mortars

Mortar Type	Average Compressive Strength P.S.I. at 28 Days	Water Retention Flow After 1 Min. Suction
M	2500	70%
S	1800	70%
N	750	70%

Note: Since it is difficult to distinguish visually between these causes of stiffening, the practical method of determining suitability of mortar is on the basis of time elapsed after initial mixing. Mortar should be used within 2½ hours when the air temperature is 80° F. or higher; within 3½ hours when the air temperature is below 80° F.

CONSTRUCTION BEDDING

All face shell and end joints shall be fully filled with mortar and joints shall be squeezed tight. Slushing of mortar into joints shall not be permitted. The first course of blocks shall be laid in a full bed of mortar.

JOINTS

Joints on all exposed surfaces shall be concave joints, V-joints or weathered joints (specify which). The joint shall be formed by striking the mortar flush, and after it is partially set, tooling with the proper shaped tool to adequately compact the surface. The tool shall be of sufficient length, not less than 22 in., that a uniform straight line is formed free from waves.

Where the wall is to be stuccoed or painted, the joint may be struck flush. Where flush joint is to be left exposed, it shall be first compacted, then repointed, and excess mortar removed.

INTERSECTING BEARING WALLS

Intersecting concrete block bearing walls shall not be tied together in a masonry bond, except at the corners. Instead, one wall shall terminate at the face of the other wall with a control joint at that point. For lateral support, bearing walls are tied together with a metal tiebar ¼ in. thick, 1¼ in. wide and 28 in. long, with 2-in. right angle bends on each end. The bends at the ends of the tiebars are embedded in cores filled with mortar or concrete. Pieces of metal lath placed under the cores support the concrete or mortar filling.

If the control joint at the intersection of the two bearing walls is to be exposed to view or subjected to weathering, the mortar shall be raked out to a depth of ¾ in. and sealed with a calking compound.

INTERSECTING NONBEARING WALLS

For tying nonbearing block walls to other walls, strips of metal lath or ¼-in. mesh galvanized hardware cloth are placed across the joint between the two walls. The metal strips are placed in alternate courses in the wall. When one wall is constructed first, the metal strips are built into the wall and later embedded in the mortar joint of the second wall.

Where the two walls meet, the vertical mortar joint is raked out to a depth of ¾ in. if it is to be exposed to view in the finished building, and calking compound is packed into the recess.

PATTERNS AND BOND

All walls shall be built plumb, true and level, to the thickness shown on the plans, and with the pattern detailed on the drawings. Where no pattern is indicated, running bond shall be used.

CONTROL JOINTS

Control joints shall be located where shown and as detailed on the plans. Control joints shall form a continuous vertical break from top to bottom of wall or from bond beam to bond beam. Provision

TABLE 2

Mortar Proportions by Volume

Mortar Type	Parts by Volume of Portland Cement	Parts by Volume of Masonry Cement	Parts by Volume of Hydrated Lime or Lime Putty	Aggregate, Measured in a Damp, Loose Condition
M	1	1 (type II)	—	Not less than 2¼ and not more than 3 times the sum of the volumes of the cements and lime used.
	1	—	¼	
S	1	1 (type II)	—	
	½		¼ to ½	
N	—	1 (type II)	—	
	1	—	½ to 1¼	

shall be made for adequate lateral stability (detail on plans). Joint shall be filled with mortar, raked back ¾ in., and pointed with a non-hardening plastic filler. Plastic filler shall be tooled to match joint or struck flush as shown in details. No reinforcing bars shall be used across a control joint.

BOND BEAMS

Bond beams shall be located where shown and as detailed on the plans. Bond beams shall be filled with concrete having a minimum strength of 2500 p.s.i. at 28 days. They shall be reinforced with not less than two No. 4 deformed bars or as shown on plans.

SOLID UNITS

At the top of all walls, and under joists, beams or other concentrated loads, solid blocks shall be provided unless a bond beam or other detail is shown. Where loads do not exceed 40 lbs. per lineal foot, the top course may be filled with mortar or concrete, in which case a layer of metal lath or closely spaced mesh shall be used in the joint below to positively hold the mortar when rodded into the core space.

Note: A bond beam serves other structural purposes and is to be preferred. Filling of cores on the site should be permitted for lighter joist loads only *and* when filling is adequately supervised.

SPECIAL UNITS AND DETAILS

The masonry Contractor shall provide and place all special units required or as shown on plans, including solid units, bond beam units, lintel units, sash jamb units, plain end units, bullnose corner units, etc. Where such units are not available from the supplier they shall where possible be cut on the site, using a power masonry saw.

Note: The Architect should determine beforehand what standard units and special units are locally available and design accordingly insofar as possible. Job site cutting should be confined to simpler cuts and kept to a minimum.

The masonry contractor shall place all anchor bolts for wood plates, setting them in mortar, and shall make provision for the building in of other details and appurtenances shown on the plans.

WEATHERPROOFING

All concrete masonry walls exposed to the weather or below ground shall be adequately weatherproofed or waterproofed, using an approved paint or other coating and applied in accordance with the directions of the manufacturer. This may include stucco, portland cement paint, acrylic emulsion paint, polyvinyl acetate, or other proven waterproofing treatments.

Refer to page 44 in this manual for further details regarding waterproofing of basement walls and page 42 for exterior wall treatment.

CLEANING

During progress of the work, every effort shall be made to keep walls, that are to be left exposed, clean. Mortar smears shall be allowed to dry for a short period and shall then be promptly removed by trowel or wire brush or both. Care shall be taken to avoid damage to the mortar joint when brushing. Mortar burrs shall be promptly removed.

At the conclusion of the work, walls shall be cleaned down, all scaffolding and debris removed and the wall left in good clean condition.

Section 3.

MODERN BLOCK MANUFACTURE

Two developments have been major factors in the evolution of the concrete masonry unit to its present day high standard of quality.

(1) Many progressive improvements have occurred in block making machines since the day of original hand-filled and hand-tamped operations. The modern block machine is completely automatic and reliable in operation. It automatically fills the mold box with the correct amount of mix, then vibrates under pressure for a controlled period, strips and delivers the block in multiple units ready for curing. This operation results not only in uniformity of quality and texture, size and shape, but also economy through automatic high speed production.

(2) The discovery of methods of producing high strength, low weight aggregate followed by the increasing availability of expanded shales, clays and slates has provided the modern block machine with the ideal aggregate for sustained quality production of strong lightweight units.

This combination — machine and aggregate — together with present day curing methods, has provided the block manufacturer with the facilities to produce lightweight masonry units having all the properties demanded by modern construction.

The block manufacturer carries a wide range and variety of sizes and shapes for all building purposes, and should be consulted for his standard dimensions and stock.

Section 4.

CHARACTERISTICS

Expanded shale lightweight masonry offers a combination of characteristics providing construction values unexcelled by any material. Some of these characteristics are listed below, and are discussed on the following pages.

- UNIFORMLY ATTRACTIVE TEXTURE
- LOW SHRINKAGE
- CLOSE DIMENSIONAL TOLERANCES
- EXCELLENT ACOUSTICS
- LOW THERMAL CONDUCTIVITY
- HIGH STRUCTURAL STRENGTH
- LIGHTWEIGHT
- HIGHLY FIRE RESISTANT
- DURABLE
- MINIMUM MAINTENANCE
- NUMEROUS PATTERN POSSIBILITIES
- PLEASING, NATURAL FINISH
- NON-STAINING AND NON-CORROSIVE
- ENDURING PAINT BASE
- EXCELLENT PLASTER AND STUCCO BASE

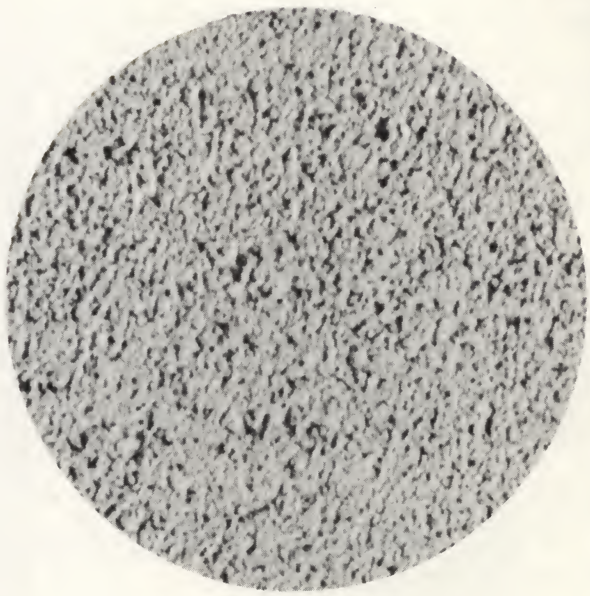
All of these characteristics are inherent in the block, and are due to the combination of properties of expanded shale aggregate.

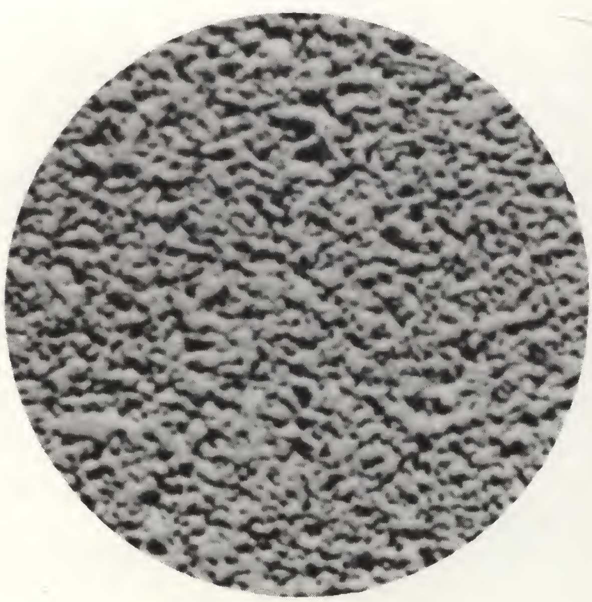
Section **5.**

TEXTURE

Architects are constantly alert for the proper materials for interior finishes — materials with the texture, color and warmth to create and complement a desired atmosphere. Often a combination of materials artistically blended produces the desired feeling. More often than not, these are single purpose materials, creating an effect, or hiding the basic wall, but adding nothing to the wall itself.

To an increasing extent, Architects are discovering that the uniformity of texture and the pleasing warmth of expanded shale masonry, create desirable effects in churches, schools, residences, offices and elsewhere. Moreover, nothing need be added to the basic structural wall or separating partition, for the finish is an integral part of the unit. This attractiveness is further enhanced by the use of one or several of the numerous coursed or random patterns. Furthermore, where painting, plastering and other effects are desired, expanded shale masonry forms an ideal base for all treatments.





Uniformity of texture is evident not only in the individual unit but also in the production run from day to day and month to month. This is the result of controlled aggregate production and block manufacturing methods. The standard texture supplied by the block manufacturer is designed to suit the needs of his customers in his area.

6.

PATTERNS & BONDS

The beauty and versatility of design, which may be derived with the standard, lightweight concrete block, would have been difficult to imagine years ago. However, as building surged from 1945 on, the need for imaginative and attractive architecture, with economy, increased enormously, both for exteriors and interiors, and developed the artistic use of this simple block to a high degree. There are many examples of the flexibility of the standard unit as utilized for public buildings, homes and churches. By utilizing various styles, a few of which are presented on the opposite page, and which are but a small portion of the unique possibilities, an effect of elegance, informality, and the esthetic may be created. Some fifty of the many patterns possible are illustrated in the Portland Cement Association publication "Patterns for Concrete Masonry".

Patterns, it will be noted, range from the familiar and simple running bond through the still simple yet effective coursed ashlars and stack bonds, to the most detailed patterned ashlars.

The choice of pattern will be governed by several factors, including:

(1) The desired effects
(2) The relative economy
(3) The availability of the desired sizes.

STANDARD SIZES

Many manufacturers of expanded shale blocks make half-height (nominal 4″ x 16″ face) and half-length (nominal 8″ x 8″ face) units, in addition to the standard unit (nominal 8″ x 16″ face). Prior to choosing the pattern, the manufacturer should be consulted as to the availability of the various required sizes.

BOND

It will be noted that a wide variety of patterns can be obtained with one or all of the three standard sizes, including running bonds, offset bonds, stack bonds and several ashlar patterns. It should also be ascertained from the local manufacturer whether he is producing a modular unit (7⅝″ x 15⅝″ face) or if some other height or length is his standard.

The terms "coursed ashlar" and "patterned ashlar" denote patterns achieved from using two to five sizes of block in a specific design. For the patterned ashlars the nominal 4″ x 4″, 4″ x 8″ and 4″ x 12″ face sizes which may be required are usually obtained most economically by cutting at the site with a masonry saw.

Ashlar patterns are also obtained by the use of scored masonry units. In some cases the scored markings must be filled with mortar and tooled to match the actual tooled mortar joints. In other cases special scoring equipment grooves the unit with a simulated concave mortar joint which it is not necessary to fill with mortar.

The most economical walls are of course the simpler running, offset and stack bonds requiring only full sized units. However, the slight additional cost of making the coursed ashlar patterns using standard units, including half height and half length units, is often more than offset by the results obtained. Even with the more detailed patterned ashlars the additional expense may well be justified by the results.

Table 12 indicates the number of units of each size required per 100 sq. ft. wall for the patterns illustrated. Also shown is the requirement for mortar given in total lineal feet per 100 sq. ft. of wall.

The numerous basket weaves are most effective, but in general are suited only to the modular units.

The structural strength and stability of expanded shale masonry laid in running bond for a load-bearing wall is proven and accepted. The

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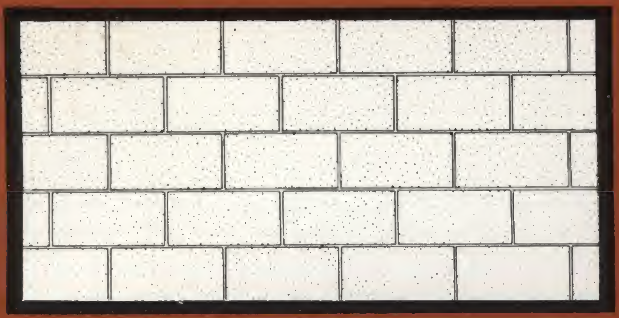
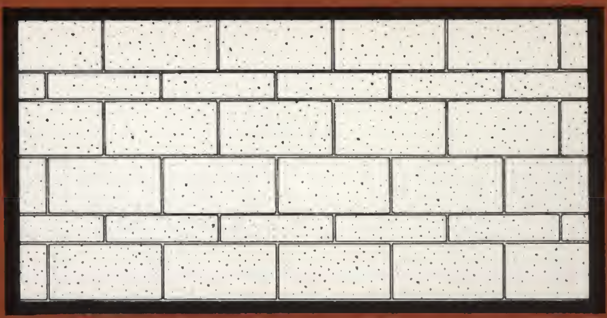
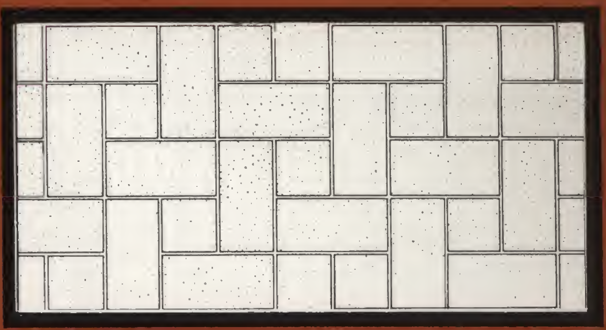


1. *Running bond, 8x16 in.*

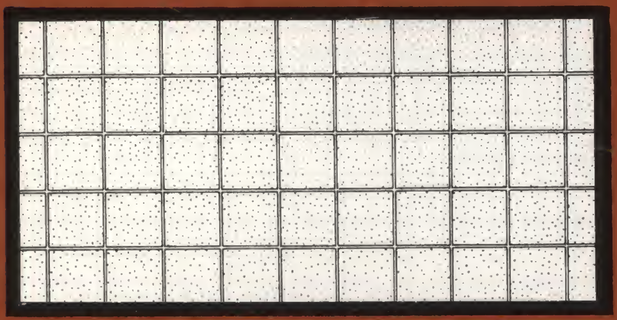


5. *Coursed ashlar, 4x16, 8x16 in.*

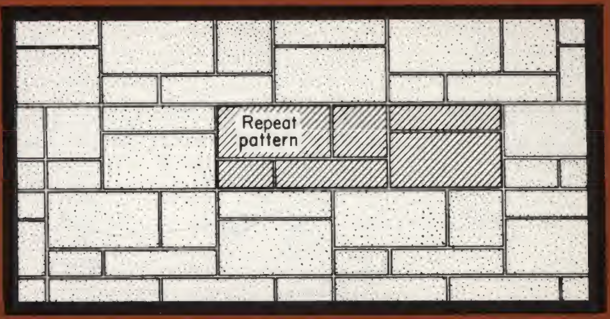
2. *Horizontal stacking, 8x16 in.*



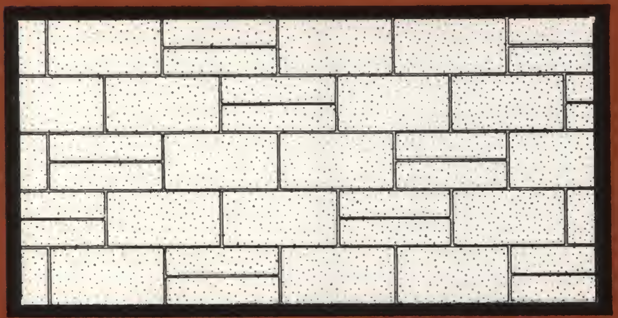
6. *Basket weave, 8x8, 8x16 in.*



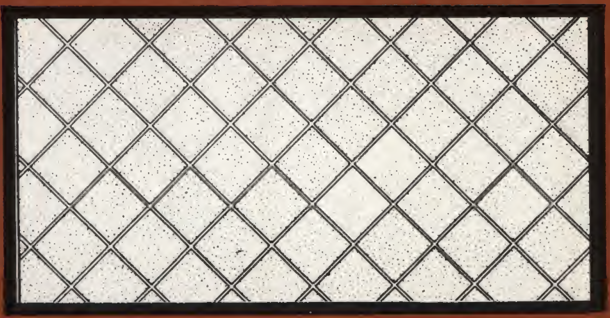
3. *Square stacking, 8x8 in.*



7. *Patterned ashlar, 4x8, 4x16, 8x8, 8x16 in.*



4. *Coursed ashlar, 4x16, 8x16 in.*



8. *Diagonal stacking, 8x8 in.*

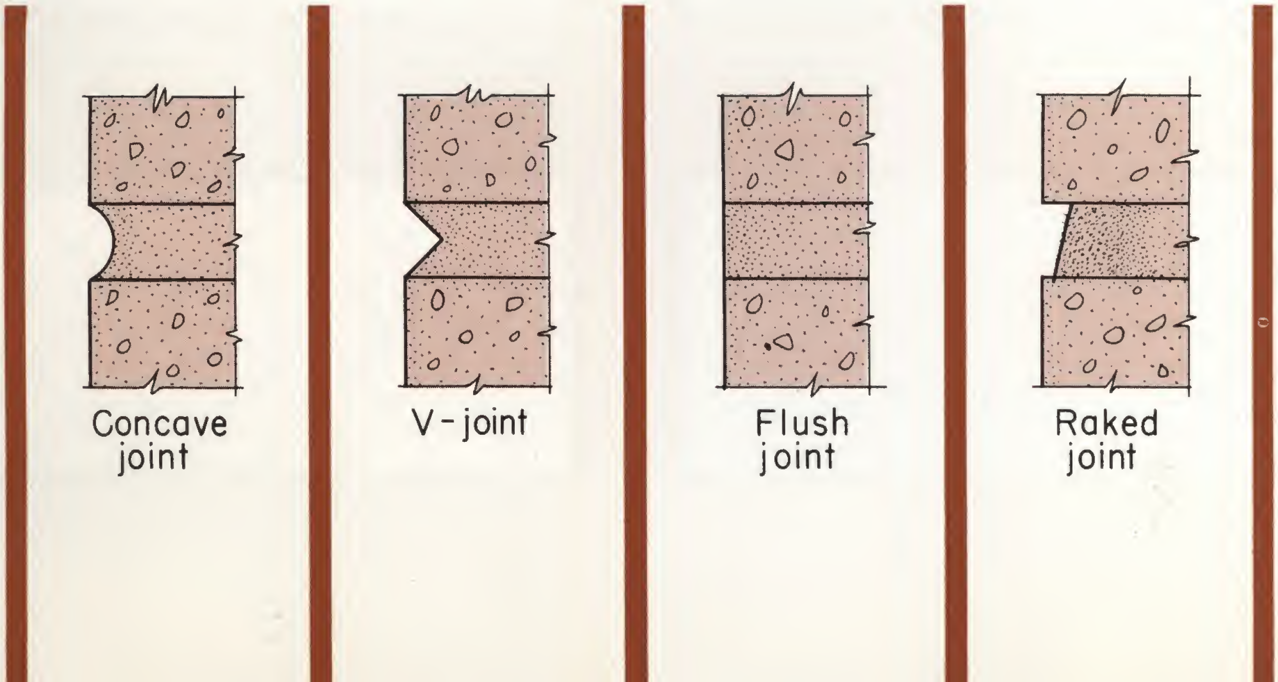
structural suitability of some of the other patterns due to the arrangement of units and joints should be evaluated and approved by the engineer for use as load-bearing walls. All patterns are suitable as non-load-bearing walls. Local codes should be consulted for any restrictions or modifications.

Note: Preliminary results of a study of the strength of various bonds indicates that, in compressive strength, even the weakest has a factor of safety in excess of four. In flexural strength on a vertical span some of the bonds tested better than running bond, whereas over a horizontal span all other patterns tested were lower.

Several possible joint treatments are illustrated in Fig. 1, namely — concave joint, V-joint, flush joint, raked joint and extruded joint. The choice will depend on the usage of the wall and on the effect desired.

V-shaped joints are usually neater in appearance and have sharp shadow lines. Concave joints are most popular and very desirable. They have less pronounced shadows. Both of these joints are widely used and for general use are to be recommended.

In the extruded joint the mortar that is squeezed out as the blocks are laid is not trimmed off but



is left to harden in its extruded form. This joint, and the raked joint, should not be used for exteriors except in relatively dry climates. These joints form ledges which may hold rain, snow or ice, and therefore may have an adverse effect on the wall.

Flush joints may be used in combination with tooled joints, to accent either horizontal or vertical lines. In this treatment the joints to be emphasized are tooled and the other joints are tooled then refilled with mortar. After the mortar has stiffened it is rubbed flush to give a texture similar to that of the block.

Tools for horizontal joints should be at least 22 in. long, preferably longer, to produce neat, straight, uniform joints without waves. For ⅜″ concave joints, a tool made from a ⅝″ round bar is satisfactory. For ⅜″ V-shaped joints a tool made from a ½″ square bar is generally used. Vertical joints are tooled with an S-shaped jointer.

PROJECTING BLOCKS

Another method of achieving different and unusual effects is available to the Architect. Certain units may be allowed to project slightly beyond the face of the adjoining units to create desired pattern and shadow effects. For certain interior use and for garden walls and screen walls, some units may be omitted entirely to achieve pleasing results. In some areas, new patterned face units with built-in shadow effects are available.

DECORATOR UNITS

The resurgence of pattern has been evident in the last few years as the public's taste, veering away from the severity typifying modern design, desires surroundings with warmth and glamour, but still with simple form. Architects throughout the United States and Canada have been sensing this and now public buildings, manufacturing plants, banks, and many other institutions, reflect the trend. There is much cooperation between the architects of the world which is producing a wealth of beautiful and functional design. At the Brussels World Fair of 1958, pattern was the most outstanding feature of the buildings representing the various countries.

There are many forms of foreign architecture ideally suited to special concrete block, such as Oriental, Scandinavian, Moorish, and Mexican. Decorators find that screen or grille block blend beautifully with the above types of architecture, and is ideally suited for commercial and residential functions. With the lightweight expanded shale units many small decorative effects can be made economically as these units are easily erected for partitions, screens, and backdrops for displays.

Note: The architect should discuss the availability of the various types of screen block with masonry manufacturers. While some screen blocks are patented many are not. See page 2 for a number of created designs using both standard and special units.

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Section **7.**

STRENGTH AND WEIGHT

STRENGTH

Concrete masonry units in most localities, depending on usage, are required to meet certain strength requirements.

The strength of concrete masonry units is measured as the ultimate breaking strength in compression and is recorded as pounds per square inch (p.s.i.) on the gross area of the unit. For example, the usual specification for a Class A unit is that the average of five units tested must be not less than 1000 p.s.i. and that no one of these units shall be less than 800 p.s.i.

While municipal, federal and other agencies may have their own codes covering acceptable quality, the most widely used specifications are those of the American Society for Testing Materials.

Expanded shale masonry units, though much lighter in weight than heavy concrete blocks, are designed to meet the same strength requirements.

Table 3 summarizes the strength limitations of three A.S.T.M. specifications to which expanded shale masonry conforms.

The superiority of expanded shale masonry is inherent in the aggregate itself. Specifically produced as a structural concrete aggregate, it has the highest crushing strength of any lightweight aggregate. The result is far less breakdown of the aggregate in the mixer or block machine, enabling the block manufacturer to more easily maintain control of strength, texture and weight.

WEIGHT

The weight of expanded shale masonry is generally the lowest of all masonry units of comparable strength. The weight of any unit will depend on its exact size, on the core volume, and on the mix used by the manufacturer. Therefore, there will be some difference between one area and another and the manufacturer should be consulted for his standard weights.

Obviously, the lowest weight, without sacrifice of strength, results in added economy due to lighter loads on the structural frame and foundation. It also means a considerably lower weight of material to be handled by the mason, or conversely, his ability to lay more blocks per day with the same expenditure of effort.

Note: The 8-8-16, 2-core expanded shale masonry units with 1¼-in. face shell weigh from 20 to 28 lbs. throughout the industry.

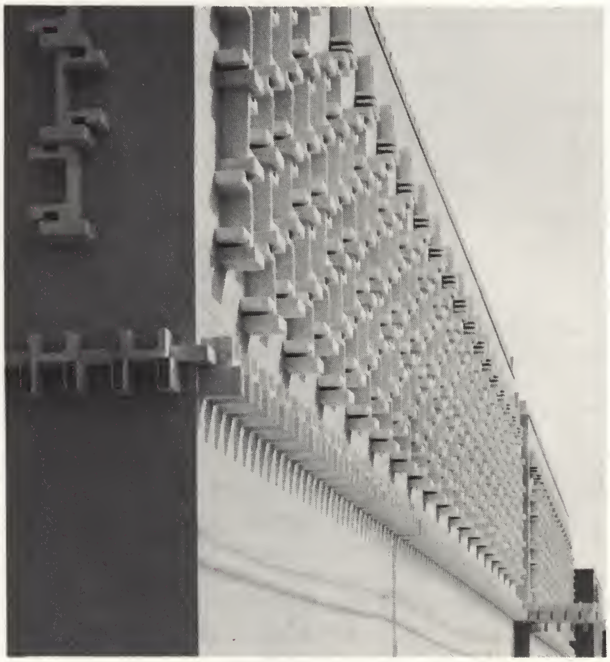

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TABLE 3

Type of Unit and Appropriate A.S.T.M. Specification Designation	Minimum Face Shell Thickness	Classification Designation	Compressive Strength-Minimum p.s.i. on Average Gross Area: Ave. of 5 Units	Individual Unit
Hollow Load-Bearing Concrete Masonry Units. A.S.T.M. Designation: C90-52	1 ¼″ or over	Grade A [a, c]	1000	800
	1 ¼″ or over	Grade B [b, c]	700	600
	Under 1 ¼″ and over ¾″		1000	800
Hollow Non-Load-Bearing Concrete Masonry Units. A.S.T.M. Designation: C 129-52	Over ½″		350	300
Solid Load-Bearing Concrete Masonry Units. A.S.T.M. Designation: C 145-52	75% or more net area	Grade A	1800	1600
		Grade B	1200	1000

[a] For use in exterior walls below grade and for unprotected exterior walls above grade that may be exposed to frost action.

[b] For general use above grade in walls not subjected to frost action or where protected from the weather with two coats of portland cement paint or other satisfactory waterproofing treatment approved by the purchaser.

[c] Regardless of the grade of unit used, protective coatings such as portland cement paint may be desirable on exterior walls for waterproofing purposes. In this connection purchasers should be guided by local experience and the manufacturer's recommendations.

Section **8.**

THERMAL INSULATION

With the many improvements being made in heating and air conditioning equipment for residences, commercial and office buildings, hotels, industrial buildings and the like, it is becoming increasingly important for architects and engineers to have ready access to information on the thermal insulation properties of building materials. This bulletin furnishes convenient information on insulating values of various walls and their components.

Since the mechanical engineer designs the heating and cooling plant on the basis of the total hourly heat transmission through the exterior parts of the building, optimum efficiency in economical structural design requires analysis of the relative heat losses through the elements of the structure. This section presents information and data on a number of commonly used building materials to aid in designing more economical structures.

The values shown in this section are based on the Heating, Ventilating and Air Conditioning Guide and may be used directly for steady state heat transmission calculations. Reference should be made to the Guide when further detailed studies are desired.

Nomenclature as used in the Guide for heat loss calculations is as follows:

U = overall coefficient of heat transmission or thermal transmittance (air to air); the time rate of heat flow expressed in Btu per (hour) (square foot) (Fahernheit degree temperature difference between air on the inside and air on the outside of a wall, floor, roof or ceiling). The term is applied to the usual combinations of materials, and also to single materials, such as window glass, and includes the surface conductance on both sides. This term is frequently called the U value.

k = thermal conductivity; the time rate of heat flow through a homogeneous material under steady conditions (through unit area per unit temperature gradient in the direction of the gradient.) Its value is expressed in Btu per (hour) (square foot) (Fahrenheit degrees per inch of thickness). Materials are considered homogeneous when the value of k is not affected by variation in thickness or size of sample within the range normally used in construction.

C = thermal conductance; the time rate of heat flow through a unit area of a material from one of its surfaces to the other per unit temperature difference between the two surfaces. Its value is expressed in Btu per (hour) (square foot) (Fahrenheit degree). The term is applied to specific materials as used, either homogeneous or hetergeneous.

f = film or surface conductance; the time rate of heat flow between a unit area of a surface and the surrounding air. Its value is expressed

TABLE 4

MATERIAL	Thickness (Inches)	Density p.c.f.	Conductivity or Conductance k	C	Resistance 1/k	1/C
CONCRETE						
Sand and gravel aggregate		140	9.00		**0.11**	
Expanded shale, clay or slate aggregate		100	3.60		**0.28**	
Expanded shale, clay or slate aggregate		95	3.30		**0.30**	
Expanded shale, clay or slate aggregate		90	3.10		**0.32**	
Expanded shale, clay or slate aggregate		85	2.80		**0.36**	
Expanded shale, clay or slate aggregate		80	2.50		**0.40**	
Expanded shale, clay or slate aggregate		75	2.30		**0.43**	
Expanded shale, clay or slate aggregate		70	2.10		**0.48**	
Cement Mortar and Stucco		116	5.00		**0.20**	
CLAY MASONRY						
Hollow clay tile	**4**			0.90		**1.11**
Face Brick		130	9.00		**0.11**	
Common Brick		120	5.00		**0.20**	
CONCRETE MASONRY						
12—8—16						
Sand and gravel aggregate	**12**			0.78		**1.28**
Cinder aggregate	**12**			0.53		**1.89**
Expanded shale, clay or slate aggregate	**12**			0.44		**2.27**
8—8—16						
Sand and gravel aggregate	**8**			0.90		**1.11**
Cinder aggregate	**8**			0.58		**1.72**
Expanded shale, clay or slate aggregate	**8**			0.50		**2.00**
6—8—16 (estimated)						
Sand and gravel aggregate	**6**			1.10		**0.90**
Cinder aggregate	**6**			0.70		**1.40**
Expanded shale, clay or slate aggregate	**6**			0.60		**1.80**
4—8—16						
Sand and gravel aggregate	**4**			1.40		**0.71**
Cinder aggregate	**4**			0.90		**1.11**
Expanded shale, clay or slate aggregate	**4**			0.67		**1.50**
FRAME CONSTRUCTION						
Siding						
Wood, Drop 1" x 8"				1.27		**0.79**
Wood, Bevel ½" x 8" lapped				1.23		**0.81**
Wood, Bevel ¾" x 10" lapped				0.95		**1.05**
Shingles						
Wood, 16-in. 7½" exposure				1.15		**0.87**
Wood, double, 16-in. 12" exposure				0.84		**1.19**
Asbestos-cement		120		4.76		**0.21**
Sheathing or Building Board						
Wood, fir or pine	**25/32**			1.02		**0.98**
Wood fiber, hardboard type	**1/4**	65		5.60		**0.18**
Plywood	**3/8**	34		2.12		**0.47**
Plywood or wood panels	**3/4**			1.07		**0.94**
Wood or cane fiber, impregnated	**25/32**	20		0.49		**2.06**
Gypsum or plaster board	**3/8**	50		3.10		**0.32**
Gypsum or plaster board	**1/2**	50		2.25		**0.45**
Building Paper						
Vapor-permeable felt				16.70		**0.06**
Vapor-seal, 2 layers mopped 15 lb. felt				8.35		**0.12**
INSULATION						
Blanket or Batts						
Mineral wool, processed from rock, slag, or glass		1.5–4.0	0.27		**3.70**	
Wood fiber		3.2–3.6	0.25		**4.00**	
Loose Fill						
Mineral wool (glass, slag, or rock)		2.0–5.0	0.30		**3.33**	
Vermiculite (expanded)		7.0	0.48		**2.08**	
Sawdust or shavings		8.0–15.0	0.45		**2.22**	
Board						
Corkboard		6.5–8.0	0.27		**3.70**	
Fiber, wood or cane (interior finish)	**1/2**	15		0.70		**1.43**
Glass fiber		9.5	0.25		**4.00**	
Wood shredded (with cement binder)		22.0	0.55		**1.82**	
Cellular glass		9.0	0.40		**2.50**	
Plaster						
Cement plaster, sand aggregate	**1/2**	116		10.00		**0.10**
Gypsum plaster						
Sand aggregate	**1/2**	105		11.10		**0.09**
Sand aggregate	**5/8**	105		9.10		**0.11**
Lightweight aggregate	**1/2**	45		3.12		**0.32**
Lightweight aggregate	**5/8**	45		2.67		**0.39**
Perlite aggregate		45	1.50		**0.67**	
Vermiculite aggregate		45	1.70		**0.59**	
SURFACE CONDUCTANCE						
f_o — for outside wall, 15 mile per hr. wind (winter)				6.00		**0.17**
f_o — for outside wall, 7½ mile per hr. wind (summer)				4.00		**0.25**
f_i — for inside wall				1.46		**0.68**
AIR SPACE CONDUCTANCE						
Vertical air space ¾" — 4'						
Winter				1.03		**0.97**
Summer				1.16		**0.86**
Reflective lining one side				0.33		**3.00**

WALL CONSTRUCTION

NOTE: Surface Resistance included in "R" for Interior Wall Treatments.

Wall No.	Construction	Interior Wall Treatment Resist. → R	Plain Wall No Plaster (R = 0.85) R_u	U	Plaster Direct On Wall: Gyp-Sand Plaster (R = 0.94) R_u	U	Plaster Direct On Wall: Gyp-Lt. Wt. Plaster (R = 1.17) R_u	U
	CAST IN PLACE OR PRE-CAST CONCRETE							
1	8" Sand & Gravel Aggregate ....140 pcf.	**0.88**	1.73	**0.58**	1.82	**0.55**	2.05	**0.49**
2	8" Expanded Shale Clay or Slate Aggregate ....100 pcf.	**2.24**	3.09	**0.32**	3.18	**0.31**	3.41	**0.29**
3	8" Expanded Shale Clay or Slate Aggregate .... 95 pcf.	**2.40**	3.25	**0.31**	3.34	**0.30**	3.57	**0.28**
4	8" Expanded Shale Clay or Slate Aggregate .... 90 pcf.	**2.56**	3.41	**0.29**	3.50	**0.29**	3.73	**0.27**
5	8" Expanded Shale Clay or Slate Aggregate .... 85 pcf.	**2.88**	3.73	**0.27**	3.82	**0.26**	4.05	**0.25**
6	6" Sand & Gravel Aggregate ....140 pcf.	**0.66**	1.51	**0.66**	1.60	**0.63**	1.83	**0.55**
7	6" Expanded Shale Clay or Slate Aggregate ....100 pcf.	**1.68**	2.53	**0.40**	2.62	**0.38**	2.85	**0.35**
8	6" Expanded Shale Clay or Slate Aggregate .... 95 pcf.	**1.80**	2.65	**0.38**	2.74	**0.37**	2.97	**0.34**
9	6" Expanded Shale Clay or Slate Aggregate .... 90 pcf.	**1.92**	2.77	**0.36**	2.86	**0.35**	3.09	**0.32**
10	6" Expanded Shale Clay or Slate Aggregate .... 85 pcf.	**2.16**	3.01	**0.33**	3.10	**0.32**	3.33	**0.30**
	CONCRETE MASONRY							
11	12" Sand & Gravel Aggregate	**1.28**	2.13	**0.47**	2.22	**0.45**	2.45	**0.41**
12	12" Cinder Aggregate	**1.89**	2.74	**0.37**	2.83	**0.35**	3.06	**0.33**
13	12" Expanded Shale Clay or Slate Aggregate	**2.27**	3.12	**0.32**	3.21	**0.31**	3.44	**0.29**
14	8" Sand & Gravel Aggregate	**1.11**	1.96	**0.51**	2.05	**0.49**	2.28	**0.44**
15	8" Cinder Aggregate	**1.72**	2.57	**0.39**	2.66	**0.38**	2.89	**0.35**
16	8" Expanded Shale Clay or Slate Aggregate	**2.00**	2.85	**0.35**	2.94	**0.34**	3.17	**0.32**
	4 INCH FACE BRICK PLUS							
17	4" Common Brick	**1.24**	2.09	**0.48**	2.18	**0.46**	2.41	**0.42**
18	4" Clay Tile	**1.55**	2.40	**0.42**	2.49	**0.40**	2.72	**0.37**
	4" Concrete Masonry							
19	Sand & Gravel Aggregate	**1.15**	2.00	**0.50**	2.09	**0.48**	2.32	**0.43**
20	Cinder Aggregate	**1.55**	2.40	**0.42**	2.49	**0.40**	2.72	**0.37**
21	Expanded Shale Clay or Slate Aggregate	**1.94**	2.79	**0.36**	2.88	**0.35**	3.11	**0.32**
22	1" Wood Sheathing, 2" x 4" Studs	**(1.54)**	..	..	..	..	..	..
	4 INCH COMMON BRICK PLUS							
23	4" Common Brick	**1.60**	2.45	**0.41**	2.54	**0.39**	2.77	**0.36**
24	4" Clay Tile	**1.91**	2.76	**0.36**	2.85	**0.35**	3.08	**0.32**
	4" Concrete Masonry							
25	Sand & Gravel Aggregate	**1.51**	2.36	**0.42**	2.45	**0.41**	2.68	**0.37**
26	Cinder Aggregate	**1.91**	2.76	**0.36**	2.85	**0.35**	3.08	**0.32**
27	Expanded Shale Clay or Slate Aggregate	**2.30**	3.15	**0.32**	3.24	**0.31**	3.47	**0.29**
28	1" Wood Sheathing, 2" x 4" Studs	**(1.90)**	..	..	..	..	..	..
	WOOD CONSTRUCTION							
29	Bevel Siding — ½" x 8" Lapped, Building Paper, Wood Sheathing, 2" x 4" Studs	**(1.91)**	..	..	..	..	..	..
	CAVITY WALLS (Built with two units, separated by 1" or larger air space)							
	9-Inch Wall							
30	4" Face Brick & 4" Common Brick	**2.15**	3.00	**0.33**	3.09	**0.32**	3.32	**0.30**
	4" Face Brick & 4" Concrete Masonry							
31	Sand & Gravel Aggregate	**2.06**	2.91	**0.34**	3.00	**0.33**	3.23	**0.31**
32	Cinder Aggregate	**2.46**	3.31	**0.30**	3.40	**0.29**	3.63	**0.28**
33	Expanded Shale Clay or Slate Aggregate	**2.85**	3.70	**0.27**	3.79	**0.26**	4.02	**0.25**
	4" Concrete Masonry & 4" Concrete Masonry							
34	Sand & Gravel Aggregate	**2.33**	3.18	**0.31**	3.27	**0.31**	3.50	**0.29**
35	Cinder Aggregate	**3.13**	3.98	**0.25**	4.07	**0.25**	4.30	**0.23**
36	Expanded Shale Clay or Slate Aggregate	**3.91**	4.76	**0.21**	4.85	**0.21**	5.08	**0.20**
	13-Inch Wall							
	4" Face Brick & 8" Concrete Masonry							
37	Sand & Gravel Aggregate	**2.46**	3.31	**0.30**	3.40	**0.29**	3.63	**0.28**
38	Cinder Aggregate	**3.07**	3.92	**0.26**	4.01	**0.25**	4.24	**0.24**
39	Expanded Shale Clay or Slate Aggregate	**3.35**	4.20	**0.24**	4.29	**0.23**	4.52	**0.22**
	4" Concrete Masonry & 8" Concrete Masonry							
40	Sand & Gravel Aggregate	**2.73**	3.58	**0.28**	3.67	**0.27**	3.90	**0.26**
41	Cinder Aggregate	**3.74**	4.59	**0.22**	4.68	**0.21**	4.91	**0.20**
42	Expanded Shale Clay or Slate Aggregate	**4.41**	5.26	**0.19**	5.35	**0.19**	5.58	**0.18**

NOTE: The average of Winter and Summer values for air space conductance is used in these calculations i.e. $\frac{.97 + .86}{2} = 0.91$.

¾ INCH FURRING															
										One Side Air Space Reflective Insulation					
⅜" Gypsum Lath						½ Inch Fiber Insulation Board				⅜" Gypsum Lath					
Gyp-Sand Plaster		Gyp-Lt. Wt. Plaster		½" Gyp. Board Dry Wall		Gyp-Sand Plaster		Gyp-Lt. Wt. Plaster		Gyp-Sand Plaster		Gyp-Lt. Wt. Plaster		½" Gyp. Board Dry Wall	
R = 2.17		R = 2.40		R = 2.21		R = 3.28		R = 3.51		R = 4.26		R = 4.49		R = 4.30	
R_u	U	R_u	U	R_u	U	R_u	U	R_u	U	R_u	U	R_u	U	R_u	U
3.05	**0.33**	3.28	**0.30**	3.09	**0.32**	4.16	**0.24**	4.39	**0.23**	5.14	**0.19**	5.37	**0.19**	5.18	**0.19**
4.41	**0.23**	4.64	**0.22**	4.45	**0.22**	5.52	**0.18**	5.75	**0.17**	6.50	**0.15**	6.73	**0.15**	6.54	**0.15**
4.57	**0.22**	4.80	**0.21**	4.61	**0.22**	5.68	**0.18**	5.91	**0.17**	6.66	**0.15**	6.89	**0.15**	6.70	**0.15**
4.73	**0.21**	4.96	**0.20**	4.77	**0.21**	5.84	**0.17**	6.07	**0.16**	6.82	**0.15**	7.05	**0.14**	6.86	**0.15**
5.05	**0.20**	5.28	**0.19**	5.09	**0.20**	6.16	**0.16**	6.39	**0.16**	7.14	**0.14**	7.37	**0.14**	7.18	**0.14**
2.83	**0.35**	3.06	**0.33**	2.87	**0.35**	3.94	**0.25**	4.17	**0.24**	4.92	**0.20**	5.15	**0.19**	4.96	**0.20**
3.85	**0.26**	4.08	**0.25**	3.89	**0.26**	4.96	**0.20**	5.19	**0.19**	5.94	**0.17**	6.17	**0.16**	5.98	**0.17**
3.97	**0.25**	4.20	**0.24**	4.01	**0.25**	5.08	**0.20**	5.31	**0.19**	6.06	**0.17**	6.29	**0.16**	6.10	**0.16**
4.09	**0.24**	4.32	**0.23**	4.13	**0.24**	5.20	**0.19**	5.43	**0.18**	6.18	**0.16**	6.41	**0.16**	6.22	**0.16**
4.33	**0.23**	4.56	**0.22**	4.37	**0.23**	5.44	**0.18**	5.67	**0.18**	6.42	**0.16**	6.65	**0.15**	6.46	**0.15**
3.45	**0.29**	3.68	**0.27**	3.49	**0.29**	4.56	**0.22**	4.79	**0.21**	5.54	**0.18**	5.77	**0.17**	5.58	**0.18**
4.06	**0.25**	4.29	**0.23**	4.10	**0.24**	5.17	**0.19**	5.40	**0.19**	6.15	**0.16**	6.38	**0.16**	6.19	**0.16**
4.44	**0.23**	4.67	**0.21**	4.48	**0.22**	5.55	**0.18**	5.78	**0.17**	6.53	**0.15**	6.76	**0.15**	6.57	**0.15**
3.28	**0.30**	3.51	**0.29**	3.32	**0.30**	4.39	**0.23**	4.62	**0.22**	5.37	**0.19**	5.60	**0.18**	5.41	**0.18**
3.89	**0.26**	4.12	**0.24**	3.93	**0.25**	5.00	**0.20**	5.23	**0.19**	5.98	**0.17**	6.21	**0.16**	6.02	**0.17**
4.17	**0.24**	4.40	**0.23**	4.21	**0.24**	5.28	**0.19**	5.51	**0.18**	6.26	**0.16**	6.49	**0.15**	6.30	**0.16**
3.41	**0.29**	3.64	**0.27**	3.45	**0.29**	4.52	**0.22**	4.75	**0.21**	5.50	**0.18**	5.73	**0.17**	5.54	**0.18**
3.72	**0.27**	3.95	**0.25**	3.76	**0.27**	4.83	**0.21**	5.06	**0.20**	5.81	**0.17**	6.04	**0.17**	5.85	**0.17**
3.32	**0.30**	3.55	**0.28**	3.36	**0.30**	4.43	**0.23**	4.66	**0.21**	5.41	**0.18**	5.64	**0.18**	5.45	**0.18**
3.72	**0.27**	3.95	**0.25**	3.76	**0.27**	4.83	**0.21**	5.06	**0.20**	5.81	**0.17**	6.04	**0.17**	5.85	**0.17**
4.11	**0.24**	4.34	**0.23**	4.15	**0.24**	5.22	**0.19**	5.45	**0.18**	6.20	**0.16**	6.43	**0.16**	6.24	**0.16**
3.71	**0.27**	3.94	**0.25**	3.75	**0.27**	4.82	**0.21**	5.05	**0.20**	5.80	**0.17**	6.03	**0.17**	5.84	**0.17**
3.77	**0.27**	4.00	**0.25**	3.81	**0.26**	4.88	**0.20**	5.11	**0.20**	5.86	**0.17**	6.09	**0.16**	5.90	**0.17**
4.08	**0.25**	4.31	**0.23**	4.12	**0.24**	5.19	**0.19**	5.42	**0.18**	6.17	**0.16**	6.40	**0.16**	6.21	**0.16**
3.68	**0.27**	3.91	**0.26**	3.72	**0.27**	4.79	**0.21**	5.02	**0.20**	5.77	**0.17**	6.00	**0.17**	5.81	**0.17**
4.08	**0.25**	4.31	**0.23**	4.12	**0.24**	5.19	**0.19**	5.42	**0.18**	6.17	**0.16**	6.40	**0.16**	6.21	**0.16**
4.47	**0.22**	4.70	**0.21**	4.51	**0.22**	5.58	**0.18**	5.81	**0.17**	6.56	**0.15**	6.79	**0.15**	6.60	**0.15**
4.07	**0.25**	4.30	**0.23**	4.11	**0.24**	5.18	**0.19**	5.41	**0.18**	6.16	**0.16**	6.39	**0.16**	6.20	**0.16**
4.08	**0.25**	4.31	**0.23**	4.12	**0.24**	5.19	**0.19**	5.42	**0.18**	6.17	**0.16**	6.40	**0.16**	6.21	**0.16**
4.32	**0.23**	4.55	**0.22**	4.36	**0.23**	5.43	**0.18**	5.66	**0.18**	6.41	**0.16**	6.64	**0.15**	6.45	**0.16**
4.23	**0.24**	4.46	**0.22**	4.27	**0.23**	5.34	**0.19**	5.57	**0.18**	6.32	**0.16**	6.55	**0.15**	6.36	**0.16**
4.63	**0.22**	4.86	**0.21**	4.67	**0.21**	5.74	**0.17**	5.97	**0.17**	6.72	**0.15**	6.95	**0.14**	6.76	**0.15**
5.02	**0.20**	5.25	**0.19**	5.06	**0.20**	6.13	**0.16**	6.36	**0.16**	7.11	**0.14**	7.34	**0.14**	7.15	**0.14**
4.50	**0.22**	4.73	**0.21**	4.54	**0.22**	5.61	**0.18**	5.84	**0.17**	6.59	**0.15**	6.82	**0.15**	6.63	**0.15**
5.30	**0.19**	5.53	**0.18**	5.34	**0.19**	6.41	**0.16**	6.64	**0.15**	7.39	**0.14**	7.62	**0.13**	7.43	**0.13**
6.08	**0.16**	6.31	**0.16**	6.12	**0.16**	7.19	**0.14**	7.42	**0.13**	8.17	**0.12**	8.40	**0.12**	8.21	**0.12**
4.63	**0.22**	4.86	**0.21**	4.67	**0.21**	5.74	**0.17**	5.97	**0.17**	6.72	**0.15**	6.95	**0.14**	6.76	**0.15**
5.24	**0.19**	5.47	**0.18**	5.28	**0.19**	6.35	**0.16**	6.58	**0.15**	7.33	**0.14**	7.56	**0.13**	7.37	**0.14**
5.52	**0.18**	5.75	**0.17**	5.56	**0.18**	6.63	**0.15**	6.86	**0.15**	7.61	**0.13**	7.84	**0.13**	7.65	**0.13**
4.90	**0.20**	5.13	**0.19**	4.94	**0.20**	6.01	**0.17**	6.24	**0.16**	6.99	**0.14**	7.22	**0.14**	7.03	**0.14**
5.91	**0.17**	6.14	**0.16**	5.95	**0.17**	7.02	**0.14**	7.25	**0.14**	8.00	**0.13**	8.23	**0.12**	8.04	**0.12**
6.58	**0.15**	6.81	**0.15**	6.62	**0.15**	7.69	**0.13**	7.92	**0.13**	8.67	**0.12**	8.90	**0.11**	8.71	**0.11**

in Btu per (hour) (square foot of surface) (Fahrenheit degree temperature difference). Subscripts i and o are used to differentiate between inside and outside surface conductances, respectively.

a = thermal conductance of an air space; the time rate of heat flow through a unit area of an air space per unit temperature difference between the boundary surfaces. Its value is expressed in Btu per (hour) (square foot of area) (Fahrenheit degree). The conductance of an air space is dependent on the temperature difference, the height, the depth, the position and the character and temperature of the boundary surfaces. Since the relationships are not linear, accurate values must be obtained by test and not by computation.

R_u = thermal resistance. Its value is obtained from the reciprocal of heat transfer as expressed by U, k, C, f or a. It is expressed in (hours) (square feet) (Fahrenheit degrees) per (Btu). For example, a wall with a U value of 0.25 would have a resistance value of $R = 1/0.25 = 4.0$. Therefore, 4 hours would be required for the transfer of one Btu for each square foot of area and each degree of temperature differential. In some cases resistance is expressed in the alternate form of degrees F per (Btu/hour square foot).

The coefficient of heat transmission U of a construction is calculated as the reciprocal of R_u which is the sum of the resistances of the various components of the wall including air spaces and surface films.

Table 4 lists the resistance from which the sum R_u can be obtained.

Example: Assume initial trial design of an 8 in. sand-gravel concrete masonry wall, furred and plastered.

Referring to Table 4:

		R
$1/f_o$	Outside surface conductance	.17
$1/C$	8×8×16 concrete masonry, sand and gravel	1.11
$1/a$	Air space (average of summer and winter values)	.91
$1/C$	Rock lath, ⅜″ thick	.32
$1/C$	Sand-gypsum plaster, ½″ thick	.09
$1/f_i$	Inside surface conductance	.68
	Total R_u =	3.28

$$U = \frac{1}{R_u} = 0.30$$

This heat loss may be acceptable under moderate climactic conditions. Where such conditions do not exist, changes in this design will be required.

Let us assume that climactic conditions dictate a heat loss of 0.25 Btu per square foot per hour, or less. This will require an R_u of 4.00, or additional resistance of $4.00 - 3.28 = 0.72$.

Referring to Table 4, it is noted that the difference in the resistances of 8 in. sand and gravel and expanded shale masonry is $2.00 - 1.11 = 0.89$.

Substituting expanded shale for sand and gravel masonry results in the initial trial design becoming $R_u = 3.28 + 0.89 = 4.17$ and U becomes 0.24, which satisfies the requirement selected.

Table 5 provides the calculated values of the overall coefficient of heat transmission U and total resistance R_u for a number of different composite walls. The use of this table by the architect and engineer generally will permit the selection of a wall design that will economically and readily meet insulation requirements without the necessity of calculations from the data listed in Table 4.

Section 9.

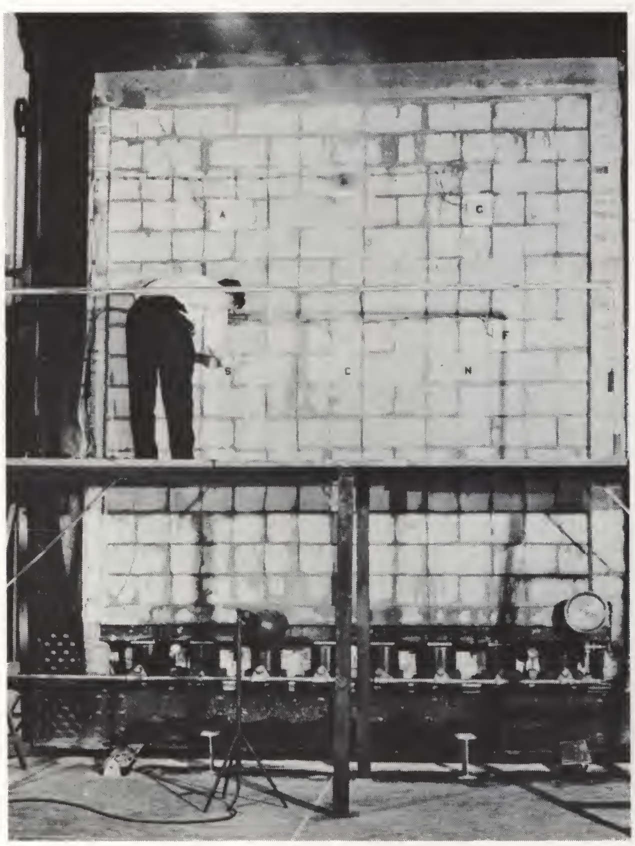
FIRE RESISTANCE

A.S.T.M. methods of testing building materials for fire resistance are designed to determine the fire-resistive properties of materials and assemblies in accordance with a common standard. The test consists of exposing the material or assembly to a fire of controlled extent and severity. Performance is defined as the elapsed period of time of resistance to this standard exposure before the first critical point in behavior is observed, and is reported in hours.

As a matter of general interest, the standard controlled fire test calls for furnace temperatures of 1000 degrees F. in 5 minutes, 1700 degrees F. in 1 hour, and 2000 degrees F. in 4 hours.

In 1958 the Underwriters' Laboratories completed a series of fire tests on expanded shale concrete masonry representative of nation-wide standard production. The program was designed to furnish fire resistance ratings on the commercially available A.S.T.M. Class A expanded shale block, and to furnish ratings on a basis of equivalent thickness and face shell thickness of 8-in. units. "Equivalent thickness" is defined as the average thickness of the solid material in the wall. It is determined by dividing the volume of concrete in the unit by the face area of the unit.

Table 6 gives the fire resistance rating of expanded shale concrete masonry.



The walls, though scorched, were structurally sound and were used for replacement building.

TABLE 6

Expanded Shale Concrete Masonry Units

(Consult your masonry manufacturer for specific units available in your area)

Source	2 Hour***		3 Hour***		4 Hour***	
	Equivalent Thickness (in.)	Face Shell Thickness (in.)	Equivalent Thickness (in.)	Face Shell Thickness (in.)	Equivalent Thickness (in.)	Face Shell Thickness (in.)
Natl. Board of Fire Underwriters Fire Resistant Ratings — April 1959						
(1:7 Mix — 8″ or 12″ units)		1 ⅛		1 ⅜		
(1:9 Mix — 8″ or 12″ units) (Class A Block)	4.20	1 ¼	4.85	1 ½	5.35	1 ¾
Estimated Ratings (1:7 Mix)	3.80		4.80		5.70	
Underwriters' Laboratories Standards for Safety UL 618, Table I, Aug. 1958						
(1:7 Mix — 8″ units)		1 ⅛		1 ⅜		
Underwriters' Laboratories Standards for Safety UL 618, Table II, Aug. 1958						
(1:9 Mix — 8″ units)	4.20	1 ¼ *	4.85	1 ½ *	5.35 4.20** 4.85**	1 ¾ *
National Fire Protection Handbook, 1954 (1:7 Mix — 8″ units)		1 ⅛		1 ⅜		1 ⅝

This table is prepared as a guide. For additional specific requirements, please refer to the source indicated.

*Approximate

**Cores filled with expanded shale. See U.L. Building Materials List January 1959.

***Rated as load bearing with noncombustible or no members framed into wall.
See N.B.F.U. Fire Resistant Ratings or U.L. Building Material List.

Section **10.**

SOUND TRANSMISSION LOSS

The control of sound in rooms of buildings may be classified with respect to the origin of the sound — namely, sounds originating within the room and sounds originating outside the room. Efficient and economical control of sound is dependent not only upon its origin, but also upon the design of the enclosure and type of occupancy.

For reduction of sound originating within a room, the sound absorption qualities of the walls, ceiling and flooring, as well as furnishings are important. The type and use of the room affords the architect latitude in the selection of sound absorption materials for elements of the room. Enclosures with high ceilings and large expanse of wall areas, as in gymnasiums and churches, might utilize sound absorbing textured masonry walls as an economical solution. On the other hand, enclosures with relatively low ceilings, and rather small exposed wall areas, as in offices and schoolrooms, accoustical ceilings, floor covering, and interior furnishings might be the more effective solution. (See Section 11.)

This section is concerned primarily with the suppression of sound originating outside the room by evaluating the transmission loss through concrete masonry partitions. These sounds are transmitted as solid-borne, as well as air-borne noise. For example, a bare concrete floor transmits the sound of footsteps between rooms, the sound traveling through the rigid concrete slab. Solid-borne sound should be suppressed at the source. A concrete floor for example, should be either broken at partitions, or covered with some type of resilient material, depending upon the extent of solid-borne sound transmission which should be suppressed.

Air-borne sound may be reduced and/or suppressed by barriers such as concrete masonry partitions. Obviously, attention should be given to doors and their closures, as well as connections of the walls at the ceilings and floors. Too often the effectiveness of a concrete masonry partition which should provide satisfactory accoustical isolation is unnecessarily lost. This may occur by failure of the designer to take into account the other important factors that are involved, such as continuing the partition to the structural ceiling. Also, he should avoid cutting of continuous holes through the wall for ducts, electrical outlets, etc.

SOUND ENERGY MEASUREMENTS

Sound energy is measured in decibels. The decibel is a convenient unit because it is approximately the smallest change in energy that the ear can detect.

The following table of sound intensities will aid in an understanding of decibel values.

TABLE 7*

Db	
160	Near jet engine
130	Threshold of painful sounds; limit of ear's endurance
120	Threshold of feeling (varies with frequency)
105	Express train passing at high speed
100	Loud automobile horn, 23 feet away
80	A subway
70	A stenographic room
60	Average busy street
55	Noisy office or department store
50	Moderate restaurant clatter
45	Average office
35	Soft radio in apartment. The average residence.
20	Average whisper four feet away
10	Rustle of leaves in gentle breeze
0	Threshold of audibility

According to various studies, the weight per unit of wall area is a most important factor influencing sound transmission loss. Knudsen and Harris** have presented a chart representing the average relationship between transmission loss and weight of the barrier. This chart was published in the November, 1956 issue of the ACI

*Building Materials and Structures Report 144, National Bureau of Standards.

**V. O. Knudsen and C. M. Harris "Accoustical Designing in Architecture," John Wiley & Sons, 1950.

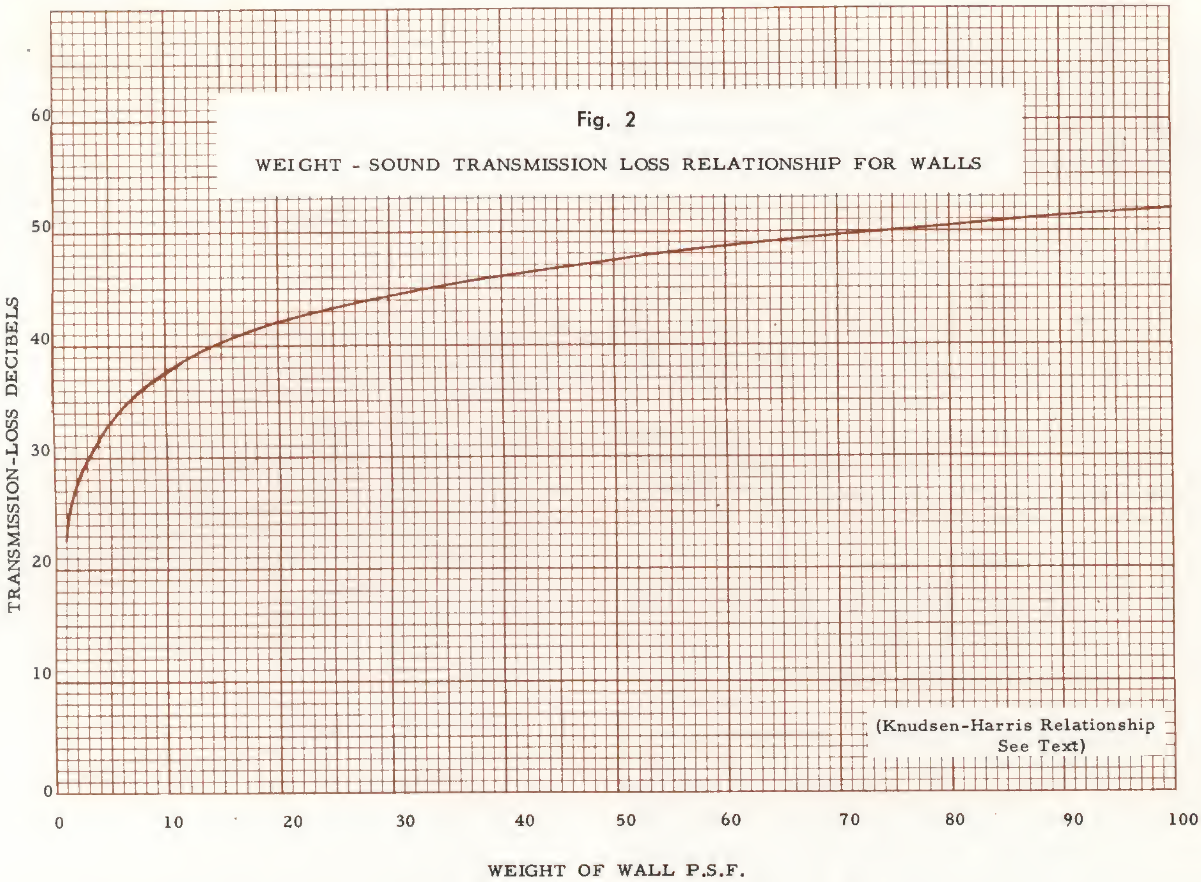


Fig. 2
WEIGHT - SOUND TRANSMISSION LOSS RELATIONSHIP FOR WALLS
TRANSMISSION-LOSS DECIBELS
0
10
20
30
40
50
60
(Knudsen-Harris Relationship
See Text)
0
10
20
30
40
50
60
70
80
90
100
WEIGHT OF WALL P.S.F.

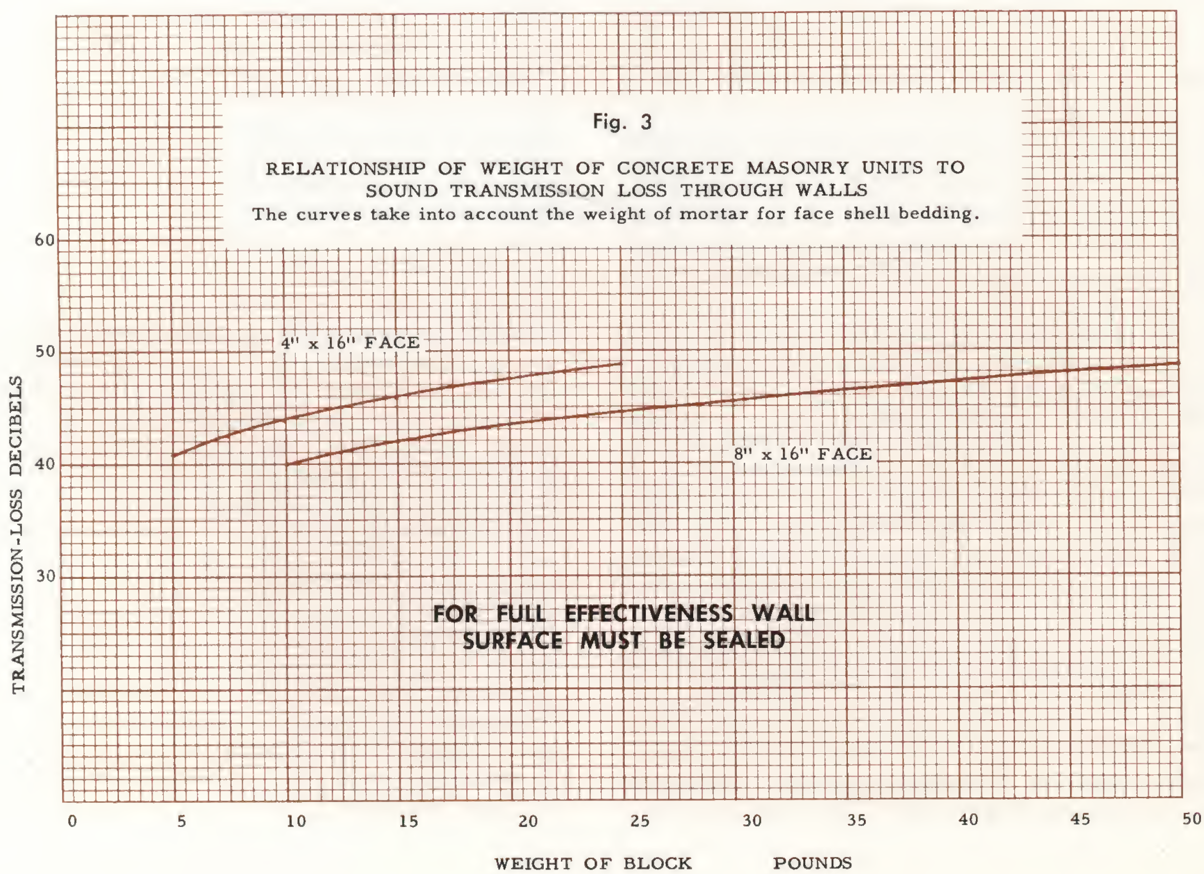


Fig. 3
RELATIONSHIP OF WEIGHT OF CONCRETE MASONRY UNITS TO
SOUND TRANSMISSION LOSS THROUGH WALLS
The curves take into account the weight of mortar for face shell bedding.
TRANSMISSION-LOSS DECIBELS
30
40
50
60
4" x 16" FACE
8" x 16" FACE
FOR FULL EFFECTIVENESS WALL
SURFACE MUST BE SEALED
0
5
10
15
20
25
30
35
40
45
50
WEIGHT OF BLOCK POUNDS

Journal* on logarithmic coordinates. Fig. 2 represents this relationship plotted on linear coordinates. Porous materials, such as concrete masonry, may be expected to follow this transmission loss-weight relationship, *provided the pores are not continuous.* It therefore follows that effectively sealing one or both sides of concrete masonry partitions is highly desirable.

Fig. 2 presents rather clearly the decreasing value of wall weight in effecting sound transmission loss. It will be noticed that whereas the first 15 lbs. per square foot of wall area furnish a loss of 40 decibels, the next fifteen pounds increase the loss only 5 decibels.

Fig. 3 relates transmission loss to the weight of concrete masonry units. The losses in these charts take into acount the weight of the mortar required to lay the wall.

USE OF DIAGRAMS

An accurate computation for the sound transmission loss through masonry partitions is much more involved than this presentation, but it is believed that for practical usage in the majority of situations this simplified presentation will be found satisfactory. Obviously, for music practice rooms, recording studios, critical patients' hospital rooms and the like, a more accurate and thorough analysis of sound suppression should be employed.

In the following discussion the general effect of masking is disregarded due to the nature of conditions considered. For practical purposes, it is assumed that the extraneous noises in and around the structure under consideration are the same. In the suburbs the general noise level is low, whereas if the same structure were located in the downtown section of a busy city, the general noise level would be 30 or 40 decibels higher. Thus, the sounds of soft music which could be heard in the suburbs would be drowned out in the downtown section. The major noise level with which this section is concerned is that originating within the structure.

The architect in considering the reduction of sound through walls separating rooms of schools, hotels, or office buildings for example, is concerned with reducing a sound intensity of say, 55 decibels to something on the order of 15 decibels or less. He is able to select these values by referring to Table 7. Referring to Fig. 3 and the curve representing an expanded shale masonry unit with an 8" x 16" face, it is found that a unit weighing 15 lbs. air dried, will offer a transmission loss of approximately 42 decibels (if properly sealed). The average 4-8-16 expanded shale masonry unit weighs approximately 15 lbs. air dried, therefore a partition wall made of these units can be expected to reduce the sound transmission satisfactorily for the assumed situation, provided of course, the surfaces of the wall are sealed sufficiently to prevent the direct passage of sound through the voids.

SURFACE SEALING

As has been stated above, porous materials such as concrete masonry may be expected to follow the transmission loss-weight curve if the pores are not continuous. Thus, sealing the wall is necessary to obtain the accoustical isolation shown in Fig. 3.

Expanded shale concrete masonry units are furnished with a variety of textures which may be classified as ranging from "fine-tight" to "coarse-open." Units with a "fine-tight" texture with "slick" on the surface may be readily sealed with a single coat of paint. Units with a somewhat coarser texture are also easily sealed with the proper application of a continuous coat of paint. Units with a "coarse-open" texture will require a little more attention. It is recommended that two coats of paint be applied in order to provide a continuous paint film. Two coats of paint properly applied, while sealing the wall, need not necessarily eliminate the appearance of "rough-surface."

Tests have indicated that in addition to plaster, portland cement, polyvinyl acetate, acrylic emulsion and other latex base paints properly applied have proven highly effective in sealing the surfaces of concrete masonry walls.

The above types of paints are furnished in a variety of colors and when applied in accordance with the manufacturer's recommendations, not only effectively seal the surfaces of the masonry walls, but also offer the architect a pleasant variety of color and color combinations for decorating purposes. In addition, with expanded shale concrete masonry, there are a variety of bonds and patterns in which the units may be laid in order to achieve further variety in the architectural treatment of interiors, and still maintain effective sound transmission loss.

CONCLUSIONS

With the general principles outlined in these sections on acoustics, it is seen that considerable latitude is afforded the designer in his approach of sound control with concrete masonry. For example, with a single unit wall separating a classroom and a corridor, a medium-open textured concrete masonry unit could be used, by plastering or thoroughly sealing with paint, the classroom side. The corridor side, left unpainted, would reduce the corridor sounds by absorption, and the sealing would enable the wall to perform as an effective sound barrier to the corridor sounds. Where cavity wall construction is used for wall partitions, open-textured units may be used provided back plastering on one side of the cavity is employed to seal the wall. These are but a few of the many approaches for the efficient use of concrete masonry.

*R. C. Valore, Jr., "Insulating Concretes," ACI Journal, November, 1956, p. 509.

Section 11.

SOUND ABSORPTION

Sound absorption control deals with the reduction of sound emanating from a source *within* the room. Control is dependent on the efficiency of the many surfaces in the room in absorbing (i.e. not reflecting) sound waves.

The study of sound conditioning and acoustical control is a highly specialized field, and for a thorough and accurate solution, particularly of special problems, authorities on the subject and more detailed manuals should be consulted. This section will serve as an introduction to some of the principles involved.

PRINCIPLE OF CONTROL

Sound waves created by voices, equipment, and other sources, radiate in all directions in a room until they strike some surface, such as the wall, ceiling, floor, or furnishings. There the energy of the sound wave is partly absorbed and partly reflected, the extent of each depending on the nature of the surface it strikes. Reduction of the amount of sound reflected therefore is essentially a matter of selection of materials for walls, floor, ceiling, and furnishings which will absorb the desired degree of sound.

In the control of sound where a speaker or music is to be heard, such as in a church or auditorium, reverberations in the room should also be considered.

ABSORPTION CRITERIA

Three terms are introduced to define and evaluate sound absorption. These are the Sound Absorption Coefficient, Sabin, and Noise Reduction Coefficient.

The Sound Absorption Coefficient is a measure of the proportion of the sound striking a surface which is absorbed by that surface, and is usually given for a particular frequency. Thus, a surface which would absorb 100% of the incident sound would have a Sound Absorption Coefficient of 1.00, while a surface which absorbs 45% of the sound, and reflects 55% of it, would have a Sound Absorption Coefficient of 0.45.

A Sabin or square-foot Unit of Absorption is defined as the amount of sound absorbed by one square foot of surface having a Sound Absorption Coefficient of 1.00. The number of Sabins (Absorption Units) of a given area is then the product of the area and the Sound Absorption Coefficient. 100 sq. ft. of a surface with a Sound Absorption Coefficient of 0.25 furnishes 25 Sabins (Absorption Units).

Most materials are tested at frequencies from 125 to 400 cycles per second (cps) in octave steps. The Noise Reduction Coefficient is the average of the Sound Absorption Coefficient at 250, 500, 1000 and 2000 cps in octave steps. Table 8 lists approximate values of the Noise Reduction Coefficients of numerous materials.

TEXTURE

The Noise Reduction Coefficient of a surface is, to a large degree, dependent on the porosity of the material and the texture of the surface.

For example, a sheet of gypsum lath with its relatively smooth paper covering would be expected to reflect a major portion of sound striking it, thereby furnishing low sound absorption. On the other hand, if the surface were punctured with a number of holes, sound could then penetrate the porous core, and be dissipated thus appreciably increasing its sound absorption.

Concrete masonry produced with expanded shale offers an extremely strong material with countless minute voids due to the technique of modern aggregate and block manufacture. These voids naturally appear on the surface of the unit, thereby permitting sound waves to enter the unit and be dissipated within the material, thus giving it fairly good sound absorbing properties.

Painting will tend to seal the surface. Tests indicate that the extent of sealing depends upon the type of paint and method of application. (See Table of Noise Reduction Coefficients.)

REVERBERATION

Reverberation is the persistence of sound within an enclosed space after the source of sound has been cut off. Its effect on hearing is to prolong syllables in speech or tones in music which, if not in the right range, make hearing difficult and irritating.

Reverberation time is defined as the time in seconds for the intensity level to fall 60 decibels.* The factors which affect reverberation time are (1) the volume of the room and (2) the sound absorbing properties of the room.

In rooms of small volume, such as offices, reverberations generally are of small consequence. In assembly areas where speech or music is to be heard, as in churches and auditoriums, an investigation of reverberation time is necessary.

Reverberation time may be computed by the formula developed by Mr. W. C. Sabine:

$$T = \frac{0.05V}{a}$$

T = reverberation time
V = volume of the room in cubic feet
a = absorption of the surface in sabins

The desirable reverberation times for hearing may be taken from the chart in Fig. 4. The shaded area on this chart represents acceptable reverberation times for various room sizes. When treating rooms with public address systems, the times should fall nearer the lower limit of tolerance. In churches or rooms without public address systems, the times selected should fall nearer the upper limits.

SOUND ABSORPTION CALCULATIONS

Tabulated or tested values of the Sound Absorption Coefficient, plus the concept of the Sabin or Absorption Unit provide a means of estimating the total sound absorbed in a room, and permits a choice of materials to accomplish the desired value.

Experience of acoustical engineers has indicated that for noise reduction comfort, the total number of Absorption Units in a room (exclusive of the absorption provided by the occupants), should be between 20% and 50% of the total surface area. The lower range is generally satisfactory for enclosures such as offices and school rooms, whereas the upper range is desirable for such areas as libraries. Where a speaker or music is to be heard by an audience, reverberation time becomes the controlling factor in comfort design.

EXAMPLES

The following examples will serve to illustrate the calculations.

*See Section 10, Sound Transmission Loss.

EXAMPLE #1

An office 15 x 25 ft. with 9 foot ceilings: medium textured concrete masonry walls sprayed with two coats of latex base paint, asphalt tile floors, and acoustical tile ceiling. Interior Surface Area = (15x25x2) + (30 + 50) × 9 = 1,470 sq. ft. 1,470 × 20% = 294, minimum number of Absorption units desired for comfort.

Floors	15×25	= 375 sq. ft. × 0.05 =	19.0
Ceiling	15×25	= 375 sq. ft. × 0.70 =	262.0
Walls	(30 + 50) × 9	= 720 sq. ft.	
Window	6× 4	= 24 sq. ft. × 0.02 =	0.5
Door	6.5× 4	= 26 sq. ft. × 0.06 =	1.5
Masonry	720 − (24 + 26)	= 670 sq. ft. × 0.36 =	241.0
		Total absorption units	524.0

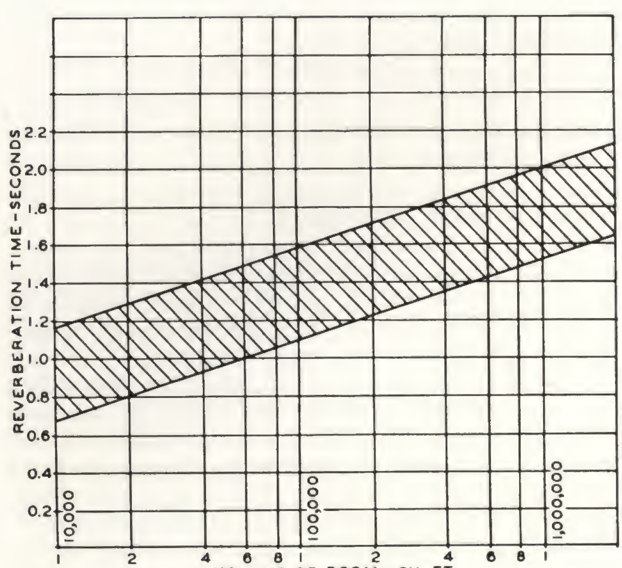
Since the total absorption units are greater than the minimum required, 294, and less than the maximum, 735, the office should be satisfactory.

EXAMPLE #2

A school auditorium or assembly room without a public address system: room 50 ft. by 70 ft. in area with 20 ft. ceilings; stage 50 ft. by 30 ft. with 30 ft. opening. Asphalt tile flooring over concrete; walls of exposed expanded shale masonry of medium texture, sprayed with one coat of paint, windows occupy 75% of one 70 ft. wall; ceiling is exposed pre-cast expanded shale concrete channel slabs; removable metal chairs provided for seating 300 people.

Fig. 4

Courtesy of Acoustical Materials Assn.



Interior Surface Area

$2(70\times50)+(240\times20)=11{,}800$ sq. ft.

Absorption Units required for comfort

$11{,}800\times0.20=2{,}360$ sabins

Floor	$50\times70=3500$ sq. ft. $\times0.05=$	175
Ceiling	$50\times70=3500$ sq. ft. $\times0.02=$	70
C/M Walls	$(170\times20)+(70\times20)\times0.25=3750$ sq. ft. $\times0.40=$	1,500
Windows	$(70\times20)\times0.75=1050$ sq. ft. $\times0.02=$	21
Stage Opening	$30\times10=300$ sq. ft. $\times0.50=$	150
	Total, bare room $=$	1,916
	Metal chairs $-300\times0.20=$	60
	Total for room	1,976

This is too low for our "Comfort Index", but since this is an enclosure where an audience listens to a speaker or an orchestra, reverberation time is the controlling factor.

Absorption Coefficient for a person is 4.2 sabins. As we fill room with people we must add $4.2-0.2$ (coefficient for chair) $=4.0$ sabins for each person.

Using formula $T=\dfrac{0.05V}{a}$

AUDIENCE	ABSORPTION	T
None	1976 sabins	1.8 sec.
75	2276 sabins	1.5 sec.
150	2576 sabins	1.4 sec.
225	2876 sabins	1.2 sec.
300 (full)	3176 sabins	1.1 sec.

Volume of the Aduitorium $=70\times50\times20=70{,}000$ cu. ft. Referring to Fig. 4, reverberation time for a room with a volume of 70,000 cubic ft. should be between 1.0 and 1.5.

The room should be satisfactory after it becomes ¼ full. As it approaches ¾ to completely full, a public address system would be helpful.

TABLE 8

Noise Reduction Coefficients

MATERIAL	APPROX. N.R.C.	
Expanded Shale Block, Medium Texture, unpainted	0.45	Add 10% for Coarse Texture, Deduct 10% for Fine Texture
Heavy Aggregate Block, Medium Texture, unpainted	0.27	Add 5% for Coarse Texture, Deduct 5% for Fine Texture

DEDUCTIONS FROM ABOVE FOR PAINTED BLOCK

PAINT TYPE	APPLICATION	ONE COAT	TWO COATS	THREE COATS
Any	Spray	10%	20%	70%
Oil Base	Brushed	20	55	75
Latex or Resin Base	Brushed	30	55	90
Cement Base	Brushed	60	90	—

MATERIAL	N.R.C.
Brick wall — unpainted	.05
— painted	.02
Floors	
Concrete or terrazzo	.02
Wood	.03
Linoleum, asphalt, rubber or cork tile on concrete	.03-.08
Glass	.02
Marble or glazed tile	.01
Plaster, gypsum or lime, smooth finish on tile or brick	.04
Same, on lath	.04
Plaster, gypsum or lime, rough finish on lath	.05
Plaster, acoustical	.21
Wood panelling	.06
Acoustical ceiling tile	.55-.85
Carpet, heavy, on concrete	.45
Carpet, heavy, hairfelt underlay	.70
Fabrics	
Light, 10 oz. per sq. yd. hung straight	.20
Medium, 14 oz. per sq yd draped to half area	.57
Heavy, 18 oz. per sq. yd. draped to half area	.63
Audience, seated, depending on character of seats spacing, etc	3.0 -6.0
Chairs, metal or wood	.20
Wood pews	.40
Same with cushions	2.00
Theatre and auditorium chairs	
Wood veneer seat and back	.50
Upholstered in leatherette	2.10
Heavily upholstered in plush or mohair	3.0 -3.5
Openings	
Stage, depending on furnishings	.25- .75
Deep balcony, upholstered seats	.50-1.00
Grills, ventilating	.15- .50

REFERENCES:

1. "Less Noise — Better Hearing", 6th Edition, Hale J. Sabine, The Celotex Corporation.
2. "Theory and Use of Architectural Acoustical Materials", 2nd Edition, Paul E. Sabine, Acoustical Materials Assn.
3. "Sound Reduction Properties of Concrete Masonry Walls", 1955, National Concrete Masonry Assn.
4. "Sound Absorbing Value of Portland Cement Concrete," by F. R. Watson and Keron C. Morrical, ACI Journal, May-June 1936.
5. "Insulating Concretes" by R. C. Valore, Jr., ACI Journal, November, 1956.
6. "The Difference Between Sound Absorption and Sound Insulation," by Robert Lindahl, News About Noise, September, 1959.

Section 12.

MORTAR

The functions of a mortar in a masonry wall are threefold:

(1) To bind the masonry units into an integrated, stable and permanent element.

(2) To effectively resist the passage of moisture either through or between it and the masonry unit.

(3) To complement the masonry unit in providing a neat and pleasing appearance.

Since the mortar is an integral part of the wall, and since some characteristics of the mortar materially affect the quality of workmanship obtained, the mortar should be designed and specified with the same care as the masonry unit itself.

Generally, the requirements of "Tentative Specifications for Mortar for Unit Masonry" — A.S.T.M. Designation C270 — may be followed except where other federal, municipal and special codes apply.

WATER RETENTIVITY

A.S.T.M. C270 requires that mortars, mixed to an initial flow of 100 to 115, shall have a flow after suction of not less than 70%

This applies to all classifications of mortars. It is a most important requirement and should be strictly adhered to. This flow is a measure of the water retentivity of the mortar, that is, its ability to resist the rapid loss of water into dry absorptive units or to bleeding when in contact with non absorptive units.

Water retentivity is essential because:

(1) It increases workability;

(2) It assures a good bond to the masonry;

(3) It keeps the mortar plastic, cohesive and adhesive;

(4) It resists the rapid loss of water into absorptive units; and

(5) It resists bleeding of the mortar.

Where materials are available as plasticizers and water retaining agents, which meet with local code requirements, they may be used in accordance with manufacturer's specifications.

STRENGTH

The strength of the mortar is primarily a function of proportion of cement to sand in the mix, but is also affected by its workability and the retention of the needed water for hydration. Mortar strength is also an indication of its durability, and therefore high strength mortars must be used in severe conditions. Table 9 shows 3 mortar types and their required compressive strength at 7 and 28 days, on 2-in. cubes.

A.S.T.M. SPECIFICATIONS

A.S.T.M. Designation C270 covers five types of mortars in each of two alternate specifications. These are "Property Specifications" and "Proportion Specifications." The specification writer should specify one or the other (not both), depending upon the circumstances of the specific job.

PROPERTY SPECIFICATIONS

Mortar shall comply with A.S.T.M. C270 in all respects as it applies to property specifications. Local available plasticizers may be used when approved by the Architect and where tests show the mortar meets the requirements of these specifications. Mortar shall be type M, S or N having minimum compressive strength and water retention as shown in Table 9, when tested in accordance with A.S.T.M. C270.

PROPORTION SPECIFICATIONS

Mortar shall comply with A.S.T.M. C270 with proportions as shown in Table 10 (Note: Where local tests and usage have indicated other admixtures and plasticizers and larger quantities of sand, these proportions may be substituted by the Architect). Mortar shall be type M, S or N.

TABLE 9

Minimum Required Compressive Strength And Water Retention

Mortar Type	Compressive Strength p.s.i. at 7 Days	Compressive Strength p.s.i. at 28 Days	Water Retention Flow After 1 Min. Suction
M	1500	2500	70%
S	1100	1800	70%
N	450	750	70%

TABLE 10

Mortar Proportions By Volume

Mortar Type	Parts by Volume of Portland Cement	Parts by Volume of Masonry Cement	Parts by Volume of Hydrated Lime or Lime Putty	Aggregate, Measured In A Damp, Loose Condition
M	1	1 (type II)	—	Not less than 2¼ and not more than 3 times the sum of the volumes of the cements and lime used.
	1	—	¼	
S	½	1 (type II)	—	
	1	—	¼ to ½	
N	—	1 (type II)	—	
	1	—	½ to 1¼	

Section 13.

VOLUME STABILITY

A better understanding of the recommendations for controlling volume change may be obtained by a discussion of drying shrinkage cracking. First, it should be clearly understood that shrinkage cracking rarely, if ever, has affected the structural stability of concrete masonry construction. The complaints regarding shrinkage cracking generally have been from the point of view of appearance. Fortunately, objectionable cracking of expanded shale masonry walls throughout the years has been infrequent. Obviously this has been due to the uniformly high quality of the aggregate and the adaptation of technically sound and proven methods of manufacturing expanded shale concrete masonry.

VOLUME CHANGE

A characteristic of portland cement is its tendency to decrease in volume with a decrease in moisture content. The drying out of a masonry wall will produce a tendency for it to shrink which, if the wall is restrained, will result in tensile stresses. If these stresses exceed the tensile strength of the wall, cracking will occur. It follows that in a given situation shrinkage stress up to a certain magnitude can be tolerated without cracking, whereas a slightly greater stress will produce a stress-relieving crack. To pin-point the critical value for all cases is rather difficult, however, current investigations throughout the concrete masonry industry are promising.

Unit shrinkage of a concrete masonry unit is dependent on:

(1) The chemical and physical properties of the aggregate;

(2) The chemical and physical properties of the cement;

(3) The gradation of the aggregate;

(4) The elastic properties of the aggregate;

(5) The proportion of cement to aggregate in the mix;

(6) The method of curing the unit;

(7) The tensile strength of the unit;

(8) The elastic properties of the unit; and

(9) The design of the unit.

Investigations are in progress to determine the significance of these factors and to improve the stability of concrete masonry.

SHRINKAGE MEASUREMENTS

To simplify the control of objectionable cracking it has been felt that a measurement of the shrinkage potential of a masonry unit is important. Three methods have been employed:

1. Modified British, which dries the unit at 120° F. and 17% R.H.
2. Rapid, which dries the unit at 212° F.
3. Reference, which dries the unit at 70° F. and 50% R.H.

The Modified British Method is used by most specifying agencies. This method is now defined by The American Society of Testing Materials as a "Tentative Method of Test for Drying Shrinkage of Concrete Block," A.S.T.M. C426-58T.

The Rapid Method has been used by some specifying agencies and is still used in certain areas.

The Reference Method is used mainly, if not solely, for research work.

Investigations have been and are being made in an attempt to correlate the potential drying shrinkage of block with cracking of walls.

MOISTURE CONTENT

Since loss of moisture results in the tendency of masonry to shrink, the moisture content of the unit at the time it is incorporated in the wall deserves consideration.

For many years the A.S.T.M. specifications for concrete masonry called for the moisture content at time of delivery to be not more than 40% of the unit's total absorption. In recent years this value has been reduced in some specifications (not A.S.T.M.) to 30% of total absorption and to 25% in arid regions.

A.S.T.M. in 1958 tentatively adopted a relative humidity method of determining moisture content as developed by Carl Menzel. This method is A.S.T.M. Designation: C427-58T, "Tentative Method of Test for Moisture Condition of Hardened Concrete by the Relative Humidity Method."

Regardless of what method is used to determine the moisture content of masonry when delivered to the job, good practice calls for keeping the units as dry as possible at all times.

GOOD PRACTICE

As the many investigations continue, the following recommendations are a sound approach in minimizing objectionable cracking in a practical and economical manner:

(1) Choice of a concrete masonry unit with favorable dimensional stability;

(2) Keeping masonry units as dry as possible at all stages, particularly during site storage as well as during laying operations;

(3) The use of prefabricated or other joint reinforcement;

(4) Providing control joints and other details to allow more freedom of construction without overstressing; and

(5) The use of bond beams.

DIMENSIONAL STABILITY

Expanded shale concrete masonry maufacturers have at their disposal a lightweight aggregate developed and produced principally for making structural lightweight concrete. They also have at their disposal technical information and modern equipment for manufacturing and curing concrete masonry. As a result expanded shale masonry units uniformly have relatively low shrinkage compared with other lightweight masonry.

PROTECTION ON SITE

The following precautions should be observed:

(1) Masonry units should be stacked with separators on planks off the ground to allow air circulation and to avoid absorption of moisture from the ground;

(2) In wet weather storage piles should be covered;

(3) Concrete masonry units should not be dampened prior to laying*; and

(4) Work in progress should be covered at the top whenever work is suspended, to prevent water from entering the wall.

JOINT REINFORCEMENT

The use of prefabricated joint reinforcement, readily available in most areas, has proved to be effective in the control of drying shrinkage cracking. While it will not necessarily eliminate all cracks, those that occur will be extremely small and scarcely noticeable. Joint reinforcement also adds strength to the wall to assist in cases of unpredictable settlement or lateral loads.

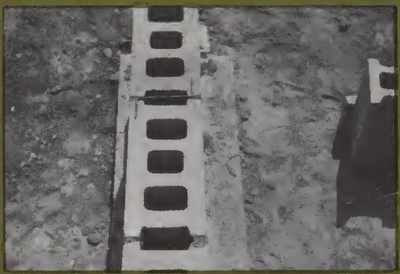
The extent of joint reinforcement required depends on the characteristics of the masonry unit, the length and height of the wall, the location of openings, and the spacing of control joints. In general, it should be used for two consecutive joints above and below windows and at other openings (unless bracketed with control joints), extending 24" beyond the opening on each side.

*In certain areas during protracted periods of hot and dry climate conditions it may be necessary to dampen block just prior to laying. It is suggested that local good practices be followed in these extreme conditions.

Control joint blocks are also made in full- and half-length units.

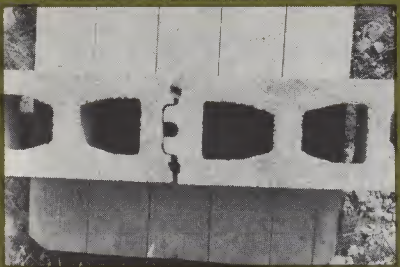
The paper or felt, across the joint, prevents the mortar from bonding.

Building paper or roofing felt, inserted in the end cores, extend the full length of the control joint.

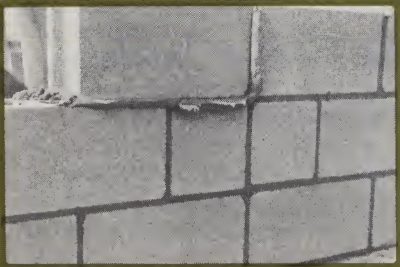


Control joints built with stretcher block have noncorroding Z-tie bars to provide lateral support.

Offset jamb block are used with a noncorroding metal tie laid across the joint.



A control joint block provides lateral support by means of tongue-and-groove-shaped ends.



To form a continuous vertcial joint, full- and half length block are used.

CONTROL JOINTS

Control joints are vertical joints which provide continuous separation in the masonry to allow freedom of movement. The adjacent photographs show typical installations.

Control joints should be located where cracking would be most likely to occur in long straight walls, and at other points of potential excess tensile stress such as abrupt changes in wall thickness, chases for pipes, or at openings, unless protected by reinforcement. They may also be used at wall intersections, at intersections of partitions and main walls and at locations of structural columns in main walls or partitions.

BOND BEAMS

The function of a bond beam is:

(1) To act as a continuous interlocking structural tie connecting the exterior load bearing walls of structures whose dimensions do not require expansion or contraction joints. They may be used between the expansion joints of larger buildings;

(2) As a structural member transmitting lateral loads on the structure to other structural elements;

(3) To reduce the effects on the masonry of differential volume changes between the foundation and superstructure walls; and

(4) As a solid member to provide bearing for floor joists or beams and to distribute concentrated loads.

In addition to the structural function, bond beams help to minimize shrinkage in masonry above and below openings.

A typical bond beam consists of a "bond beam" or "lintel" unit of the same material and texture as the wall block. They are filled in place with 2500 p.s.i. concrete and reinforced with a minimum of two No. 4 bars.

TABLE 11

Suggested Maximum Wall Lengths
(As determined by Control Joints or Corners)

	Joint Reinforcing		
	None	Alternate Courses	Each Course
	EXTERIOR WALLS		
Moderate Volume Change Units	25	30	35
Low Volume Change Units	30	40	50
	PARTITION WALLS		
Moderate Volume Change Units	25	35	45
Low Volume Change Units	35	45	55

This table should be used merely as a guide. Engineering judgment and particularly performance records and reliable shrinkage values of specific units where available should supersede these suggestions.

REFERENCES

1. "Relation of Shrinkage to Moisture Content in Concrete Masonry Units". Housing and Home Finance Agency Paper No. 25.
2. "Physical Properties of High Pressure Steam-Cured Concrete Block". Progress report of A.C.I. committee 16. A.C.I. Journal April 1953.
3. "Shrinkage Characteristics of Concrete Masonry Walls". Housing and Home Finance Agency Paper No. 34.
4. "Effect of Curing on the Properties Affecting Shrinkage Cracking of Concrete Block". A.C.I. Journal May 1955.
5. "Shrinkage and Temperature Stresses in Masonry". A.C.I. Journal February 1957.
6. "Investigation of the Moisture - Volume Stability of Concrete Masonry Units". Portland Cement Association Development Department Bulletin D3, March 1955.
7. "Measuring Shrinkage of Concrete Block — Comparison of Test Methods". A.S.T.M. Vol. 57, 1957.
8. "Modified British Method of Test for Drying Shrinkage of Concrete Products", U. S. Engineers' Handbook for Concrete and Cement, CRD-C 3-57.
9. "Tentative Method of Test for Moisture Condition of Hardened Concrete by the Relative Humidity Method", A.S.T.M. Designation: C427-58T.
10. "General Considerations of Cracking in Concrete Masonry Walls and Means for Minimizing It," Portland Cement Association Development Department Bulletin D20, September 1958.
11. "Tentative Method of Test for Drying Shrinkage of Concrete Block," A.S.T.M. Designation: C426-58T.
12. "Fallacies in the Current Per Cent of Total Absorption Method for Determining and Limiting the Moisture Content of Concrete Block," Portland Cement Association Research Department Bulletin 84, October 1957.

Section 14.

COATINGS

Coatings for concrete masonry walls serve a variety of purposes. They add color and tone for architectural and decorating purposes; they serve to waterproof the walls; the acoustical properties of the wall are enhanced; fire resistance value is added to the walls; thermal insulation value is gained.

Concrete masonry offers an excellent base for all types of coatings. Due to the variety of purposes of coatings, this section will be limited to the general aspects of paint and plaster applications to concrete masonry.

PAINTS

Concrete masonry affords an excellent base for paint. Paints may be obtained which add a variety of color and tone to walls as well as waterproofing exterior walls. Proper application of paints is important and attention should be given to the manufacturer's recommendations.

EXTERIOR

Weatherproofing tests and performance records indicate that portland cement base, polyvinyl acetate emulsion, acrylic emulsion, and styrene-butadene emulsion paints are satisfactory for exterior work. Current developments indicate that combining portland cement with some of these emulsions results in highly satisfactory exterior treatments.

INTERIOR

In addition to the paints which are satisfactory for exterior use, other latex base as well as oil base paints may be used for interior work. Frequently, depending upon the texture of the masonry wall, one application of paint will be found satisfactory as to the appearance viewpoint.

Tests indicate that the method of application, i.e., sprayed, brushed or scrubbed, as well as the type of paint influences the effectiveness of continuous films for sealing a wall.

Where the wall is to be thoroughly sealed to control sound transmission loss, care must be taken to obtain and assure a continuous film of paint. Where sound absorption of the wall is of importance, a continuous film is not advisable.

SPECIFICATIONS

The following specifications and references will be found useful:

(1) Interim Federal Specifications: PAINT, POLYVINYL ACETATE EMULSION, EXTERIOR, TT-P-0055a (Army-CE) 21 May 1958

(2) PAINT, STYRENE-BUTADIENE EMULSION, EXTERIOR, TT-P-0099 (Army-CE) 21 May 1958

(3) PAINT, ACRYLIC EMULSION, EXTERIOR, TT-P-0019a (Army-CE) 21 May 1958

(4) Suggested Specifications for Application of Portland Cement Paint on Exposed Concrete Masonry Walls — Portland Cement Association.

(5) Paint for Exterior Masonry Walls — BMS 110, National Bureau of Standards 1947.

(6) Paint Manual — BMS 105, National Bureau of Standards.

STUCCO AND SHOTCRETE

Portland cement stucco and shotcrete are exterior wall coverings which, if properly applied, fulfill all requirements of durability and give a satisfactory appearance. The primary difference in the two is the method of application. Stucco is applied by trowel; an air pressure gun is used for shotcrete.

Attention should be called to the fact that shotcrete is the term applied to all types of pressure-applied portland cement plasters furnished under various trade names such as: Gunite, Jetcrete, Bondact, Colorcrete, etc.

MATERIALS

The basic ingredients of each are portland cement, sand, and water. Natural sand is generally used and proper gradation should conform more nearly to a "concrete sand" than to a "plaster sand". Expanded shale sand has also been used, however it is generally applied as shotcrete.

SPECIFICATIONS

Reference is made to the following specifications and recommendations:

(1) Standard Specifications for Portland Cement Stucco and Portland Cement Plastering — American Standards Association 1946 (A 43.2 and A 43.3).

(2) Plasterer's Manual for Applying Portland Cement Stucco and Plaster — Portland Cement Association.

(3) Suggested Specifications for Portland Cement Stucco on Concrete Masonry Walls — Portland Cement Association.

(4) Shotcrete — Portland Cement Association.

(5) Gunite Specifications and Recommended Practice — Gunite Contractors Association 1954.

EXPANDED SHALE SHOTCRETE

Expanded shale lightweight fine aggregate has been used for shotcrete since 1948 with good results. Most of the activity has been on the Pacific coast and in the Southwest, however, there have been interesting applications in other parts of the U. S. and in Canada.

Apparently the major difference encountered in the application of expanded shale shotcrete has been in the control of re-bound. Initially the operator experiences a somewhat greater re-bound, however by standing slightly farther away from the wall, the re-bound is controlled more easily. A number of operators have found that the re-bound material can be reclaimed and reused without any detrimental effects.

Generally it is found that the expanded shale fine aggregate should be damp for efficient operation . . . not necessarily soaked, but containing perhaps one half to two thirds of its total absorption.

In some cases adjustments in the nozzle velocity have been found helpful, but this is not always necessary.

As with natural sand, the gradation of the aggregate should be slightly on the coarse side, perhaps with a fineness modulus from 2.8 to 3.3.

Satisfactory results have been obtained with a mix proportion from 1:3 to 1:5½.

Section **15.**

BASEMENT WALLS

NCMA Photo

Watertight basements are important in providing dry, healthful space for recreation rooms, workshop, service rooms and storage for many household articles. Concrete masonry has general acceptance for basement construction. It is low in cost, has great durability and in addition furnishes insulation.

Furthermore, the exposed interior masonry affords attractive low cost walls for basement recreation rooms. Expanded shale masonry basements can be built watertight simply by taking proper care in design and construction. It costs much less to build a watertight basement than to repair a leaky one. Consequently, the time to make a basement watertight is during construction.

Basement walls of expanded shale concrete masonry should meet local building code requirements as to thickness and strength of units. In the absence of a local building code, units meeting the A.S.T.M. specifications for quality should be specified.

Concrete masonry should be laid up with a Type M or S mortar composed of the proportions given in Table 10, on page 37.

A full bed of mortar should be placed on the footing to receive the first course of block. Face-shell bedding should be used on all succeeding courses with full mortar coverage on vertical and horizontal face shells. Joints should be ⅜ in. thick. Joints should be firmly compacted, after the mortar has stiffened, with a rounded tool having a diameter slightly larger than the thickness of the joint.

The earth side of concrete masonry basement walls should be parged with portland cement plaster applied in two coats of ¼ in. thickness. The plaster should be made in the proportions of 1 volume of portland cement and 2½ volumes of damp, loose mortar sand.

Wall surface should be dampened prior to application of first coat. The first coat should be roughened after it has partially set and then permitted to harden for at least 24 hours before the second coat is applied. The first coat should be dampened prior to application of second coat. The second coat should be kept damp for at least 48 hours after application.

The parged exterior surface of the basement wall should be given two continuous coatings of hot bituminous material applied at right angles to each other over a suitable priming coat, extending from 6 in. above the ground line down over the top of the footing. The wall must be surface dry when primer is applied. The primer should be dry before the hot bituminous material is applied.

No filling against the concrete masonry basement walls should be permitted until the first floor is in place.

REFERENCES:

1. Suggested Specifications for Concrete Footings and Concrete Masonry Walls
   Portland Cement Association
2. Recommended Practice for Building Watertight Basements
   Portland Cement Association

Section **16.**

ESTIMATING QUANTITIES

TABLE 12

Net Estimating Quantities
Of Expanded Shale Blocks For
Various Wall Patterns

Pattern Nos.*	Number of Units Per 100 Sq. Ft. of Wall (Modular Blocks With ⅜" Mortar Joint) NOMINAL SIZES				Lineal Ft. Mortar Joints Per 100 Sq. Ft. Of Wall
	8x16	4x16	8x8	4x8	
1, 2	112.5	....	....	....	222
3	....	....	225.0	....	293
4	75.0	75.0	....	....	271
5	90.0	45.0	....	....	251
6	100.0	....	25.0	....	230
7	60.0	60.0	30.0	30.0	285
8	....	....	225.0	....	293

*See page 17.

Section 17.

SHOCK TEST

As stated earlier, good materials, good design, and good workmanship combine to furnish the consumer with a strong, durable, low maintenance structure. In 1955 the opportunity was afforded the construction industry to demonstrate this truth in a rather spectacular and awe-inspiring test. Five members of the Expanded Shale, Clay and Slate Institute took advantage of this opportunity. The time was June, 1955. The place was Yucca Flat, Nevada. The test was "Operation Cue" to see how homes and other commercial construction would stand up to a nuclear blast.

The following is a digest of the official report of the performance of the reinforced expanded shale concrete and reinforced expanded shale concrete masonry houses in this test. We believe this performance is a tribute not only to expanded shale but to the entire concrete industry.

* * *

A properly built expanded shale concrete house — either of masonry units, precast slabs, or a combination of these materials—can afford much of the protection from an atomic blast (as well as from earthquakes, tornadoes and hurricanes) that a specially constructed bomb shelter can.

In addition, such a house will provide protection from the deadly radioactive fallout which follows an atomic blast.

These are conclusions drawn by project consultants following the Civil Defense "Operation Cue".

OPERATION CUE

The nuclear device used in "Operation Cue" had an explosive force equal to 35,000 tons of TNT — 50 percent more powerful than the atomic bomb dropped in Hiroshima.

The test was conducted jointly by the Atomic Energy Commission, the FCDA, and private industry, as a contribution to the Civil Defense Program.

Project 31.1, "Damage to Conventional and Special Types of Residences Exposed to Nuclear Effects," was one of approximately 70 projects which comprised "Operation Cue." It was a continuation of FCDA tests on residences which began as a part of "Operation Doorstep" in the spring of 1953.

Project 31.1 included five different residential types, two of each being constructed and exposed to the nuclear blast. Two small "villages" were constructed along the blast line. One was 4700 ft. from ground zero and the other at 10,500 ft.

The expanded shale concrete masonry house and the expanded shale lightweight structural precast concrete house, 4700 ft. from ground zero, were exposed to the same shock wave intensity and overpressure as a one-story frame and a two-story brick veneer house.

The blast wave from the shot of the 35 kilo ton device used for "Operation Cue" subjected all structures at the 4700-ft. line to an overpressure of approximately 5 p.s.i.

CONVENTIONAL CONSTRUCTION USED IN TEST

The concrete masonry houses were not "souped up" for this test. Walls were moderately reinforced with half-inch steel rods vertically placed 32 inches apart, in accordance with the California building code. Horizontal reinforcing was in bond beams and lintels. Construction of room partitions was identical with outside walls. Roof was constructed of six-inch reinforced lightweight, expanded clay concrete slabs. Foundation was a

flat slab with a thickened edge which formed a beam around the perimeter. The house contained 1000 square feet.

DAMAGE REPORT

All four concrete houses came through the terrific explosion far better than had been generally expected. There was no important structural damage, and equipment and furniture stored in the houses were remarkably well protected.

HOUSES AT 4700 FEET

The lightweight concrete houses on "Doomsday Drive," only seven-eighths of a mile from the tower on which the atomic device was mounted, were the only houses left standing at the 4700-foot line after the blast. They suffered only slightly cracked walls and broken windows.

Following is the official post-shot statement by the Industry Liaison Office of the Federal Civil Defense Administration:

"The above ground portion of the two-story brick and cinder block house located 4700 feet from the explosion was almost completely destroyed, and the first floor system was partially collapsed into the basement. None of the brick work remained standing, and the structure as a whole was beyond repair even for emergency shelter from the elements.

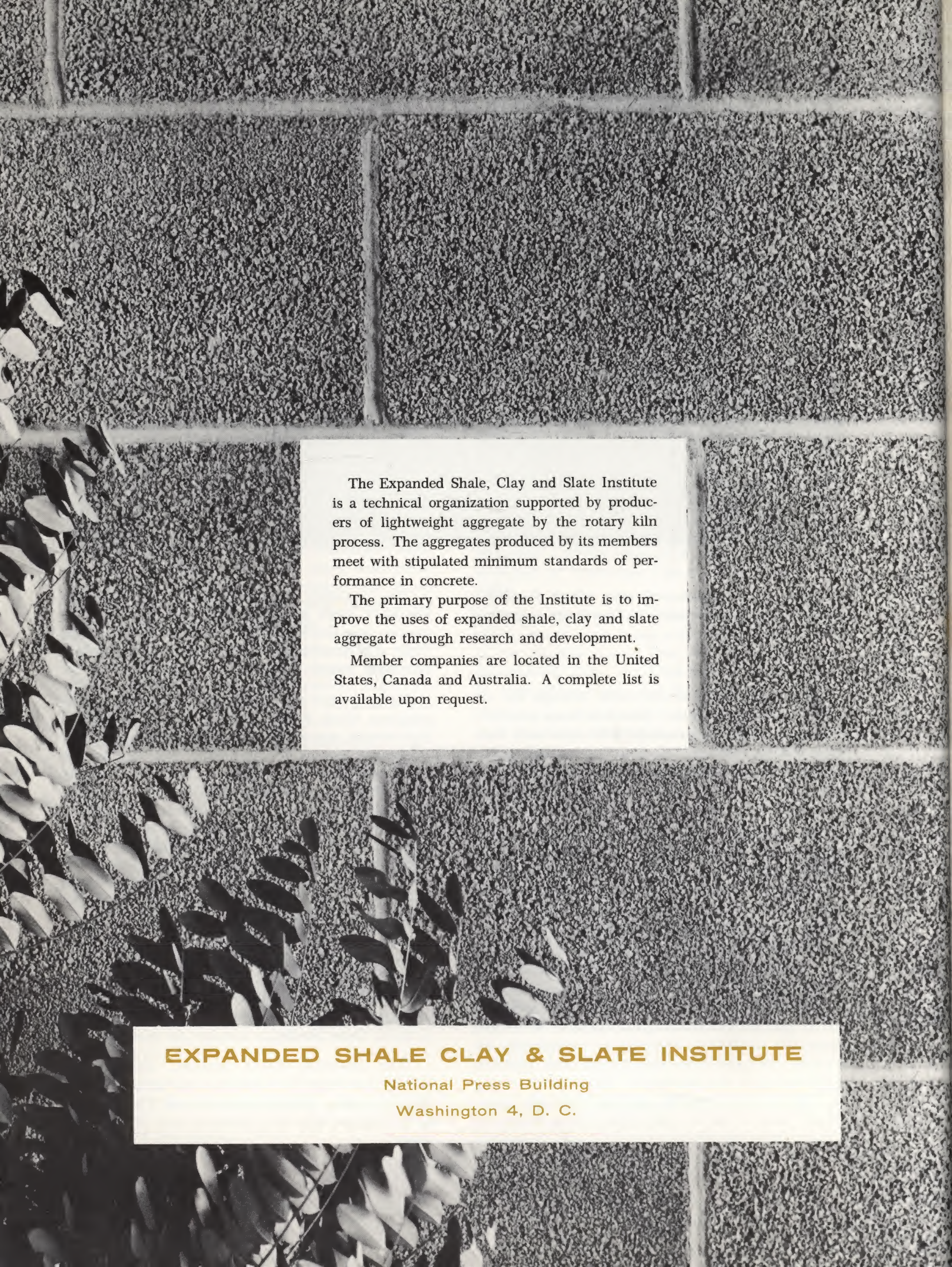
"The one-story frame rambler located near the two-story brick dwelling 4700 feet from the explosion was likewise almost completely destroyed. Only the reinforced concrete bathroom shelter remained intact.

"Both the one-story lightweight expanded shale concrete block house and the one-story precast lightweight concrete house suffered only minor structural damage. These houses were also located 4700 feet from the explosion. With the replacement of doors and window sash, both houses could be made habitable.

"At 5500 feet from the explosion the two-story redesigned frame house suffered severe damage, and would not be suitable for occupancy without extensive major repairs which would hardly be economically advisable.

"The one-story precast expanded shale light aggregate concrete house and the one-story reinforced masonry block house, both located 10,500 feet from the explosion, suffered relatively minor damage. Only minor repairs would be required to make these dwellings suitable for re-occupancy.

"The one-story frame rambler, also located 10,500 feet from the explosion, suffered relatively heavy damage, but nevertheless could be restored to conditions suitable for occupancy at moderate costs."



The Expanded Shale, Clay and Slate Institute is a technical organization supported by producers of lightweight aggregate by the rotary kiln process. The aggregates produced by its members meet with stipulated minimum standards of performance in concrete.

The primary purpose of the Institute is to improve the uses of expanded shale, clay and slate aggregate through research and development.

Member companies are located in the United States, Canada and Australia. A complete list is available upon request.

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